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ENGLISH CYCLOPÆDIA.

DEDICATED, BY PERMISSION, TO HER MAJESTY.

NATURAL HISTORY

OR

Second Division of "The English Cyclopædia,"

CONDUCTED BY

CHARLES KNIGHT.

SUPPLEMENT.

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NATURAL HISTORY.

SUPPLEMENT.

The abbreviations E. C. *and* E. C. S. *signify the English Cyclopædia and English Cyclopædia Supplement.*

ABLABES, a genus of Colubrine snakes, the species of which have an extensive geographical range. There are several species in the Himalaya Mountains, which are interesting on account of their mode of distribution, different species characterising different horizontal zones. Thus *A. collaris* occurs in the plains at the foot of the Himalayas, but is not met with higher than 3400 feet up its flanks. *A. Rappii* has not been found below about 5000 feet. *A. Owenii*, which was formerly considered to be a distinct species, is now known to be the young of *A. Rappii*. The adult differs from the young as regards colour. *A. Rappii* is uniformly blackish on the upper surface; while *A. Owenii* is greyish brown, with a broad black collar and some black transverse blotches. In both, the under parts are of a uniform yellow. The length of *A. Rappii* is 16½ inches; that of *A. Owenii* only 7¾ inches. There are seven other species described in Dr. Günther's Monograph on the Reptiles of British India, published by the Ray Society. Still more recently ('Annals of Natural History,' 4th series, i. p. 417) the same author has described a new species, *A. bistrigatus*, from Pegu. There are three species living in Palestine, viz., *A. coronella*, *A. modestus*, and *A. decemlineatus*. Nova Scotia also has a representative of the genus in its *A. punctatus*.

ABRAZITE, a mineral belonging to the zeolite family. Its composition according to the unitary system of notation, is $8\,(Ca\,KO\,Si\,O_2) + 4\,Al_2\,O_3\,Si\,O_2 + 18\,H_2\,O$. It is of a greyish white colour, transparent or translucent, and easily soluble in acids. It occurs (frequently with phillipsite) in quadratic octahedrons, which are sometimes separate, and sometimes aggregated into mammillated masses. It has been found in cavities in lava at Capo di Bove, near Rome, on Vesuvius, and at Aci Castello in Sicily. Hardness, 4·5; specific gravity, 2·265.

In the mineralogical articles of this Supplement the chemical formulæ will be expressed, unless otherwise stated, according to the unitary system of notation. In many instances two formulæ will be given, the one being that assigned to it in Watt's 'Dictionary of Chemistry,' and the other a shorter mode of expression adopted here on account of its simplicity and convenience. Thus the short expression of the formula given above is $Ca : Al.\,Si\,O_4 + 2\,H_2\,O$. Both correspond to the same per-centage composition which in this case would be as expressed in column 1, while the result obtained by actual analysis by Marignac is shown under column 2.

Silica	33·3	35·88
Alumina	31·4	27·23
Lime	15·5	13·12
Potash	—	2·85
Water	20	21·10

If the water be excluded, the proportions of the other ingredients are the same as in anorthite, a felspar which, like abrazite, is met with in the cavities of old lava flows.

ACADIOLITE, a variety of chabasite [CHABASITE, E. C. and E. C. S.].

ACALEPHÆ [E. C. vol. i. cols. 23—48]. The great bulk of the supplementary remarks which we have to make respecting this group will be found under HYDROZOA, E. C. S.; but a few lines may be given here in order to contrast the present state of our knowledge with the general ideas contained in the old article.

The old article affords a good illustration of the confusion which results from the incomplete examination of animals, which is, unfortunately, sometimes thought to be sufficient to give an observer a right to name a species. Under the article HYDROZOA, E. C. S., is indicated how former observers have referred to corresponding parts of the different species as being sometimes behind, sometimes in front, sometimes uppermost, and sometimes lowermost, although in reality these may in every case have the same relative position to the other parts of the animal. The difficulties under which the knowledge was obtained may be a pardonable excuse for the error, but nevertheless the error was none the less a source of confusion. It was much the same as if a student of the Vertebrata were to call that part the back which was generally farthest away from the ground, and to describe the sloth as having its legs situated on its dorsal side, because it generally travels in the position shown in the article BRADYPUS, E. C. vol. i. col. 646; or to refer to the inflated spiny-covered stomach of the sun-fish as being its back, because it is usually uppermost. Such mistakes would not be made by anyone who had carefully studied the structural plan upon which these creatures have been formed, or who had acquired a fair knowledge of the changes of shape through which the individuals of a species pass between their birth and ultimate decay. The neglect to acquire the latter kind of knowledge before imposing specific, generic, and other names upon the specimens found, has given rise to many of the misconceptions in the Cyclopædia article. The genera there noticed are for the most part described and figured as though they were independent forms, although they are simply the adult states or reproductive zooids of other zooids, which have other generic names, and many of which are grouped under the suborder *Hydroida* of Johnston. For example, under HYDROIDA, E. C., there is mentioned a genus *Coryne*, and under ACALEPHÆ another genus *Oceania*. According to the classification, the two names do not belong to the same class nor even order of beings, although we now know that some species of *Coryne* are simply *Oceaniæ* at an early stage of development. The mistake would be paralleled if an entomologist were to classify butterflies in one order and their caterpillars in another. Another source of confusion has been the raising to generic distinction the separated halves of many of the *Diphydæ*. In the Cyclopædia it will be noticed that this family is divided into two sections, under one of which are grouped the so-called monogastric genera, and under the other those which have two distinct cavities. Many of the former are known to be, while probably all are, the detached portions of zooids of the polygastric diphydæ. At present it is not known to what genera they are to be assigned, so that for the present it has been proposed to call them *Diphyo-zooids* until more accurate information shall enable us to discard the generic names which they now bear. For instance the *Cuboides vitreus*, *Calpe pentagona*, *Abyla trigona*, *Pyramis tetragona* of the Cyclopædia, the representatives of four genera, are probably fragments and different states of one and the same species—*Abyla pentagona.* Notwithstanding all we have said, there still remains much in the article worth consideration. The figures are for the most part fair representations of the objects they are intended for, although in one or two cases they do not quite express the appearance of the living animals, from having been drawn probably from specimens preserved in spirits of wine: as, for instance, the figure referred to *Physalus pelagicus*=*Physalia pelagica.* The descriptions are correct if care be taken to assign the proper names to the parts described, which may be ascertained by reference to HYDROZOA, E. C. S. We may notice that *Noctiluca* and *Doliolum* do not belong to the *Acalephæ:* the former appertains to the *Infusoria,* and the latter to the Molluscan sub-kingdom. Other genera are also now assigned to other places in the classificatory system: thus *Beroe, Calymma, Callianira,* and *Cestum,* are all members of the order *Ctenophora* in the allied class *Actinozoa.*

ACANTHODES. The information in E. C. concerning this genus consists of a few facts scattered amongst several articles in the following places, viz., E. C. vol. i. col. 49; ii. 28; 825; and iv. col. 160. The genus is an interesting one, inasmuch as it presents a combination of characters which are subdivided, and distributed amongst several orders of existing fishes. All the species have an elongated form, a strongly heterocercal tail, a large pendent belly, and a prominent lower jaw. The body is covered with exceedingly minute rhomboidal plates, in simple apposition with one another, and not interlocked together. They possessed large pectoral fins, and a well-developed caudal fin; also dorsal, anal, and ventral fins, the last being generally very small, and, indeed, it is seldom that any signs of them are to be detected in most fossil specimens. The anterior margin of most of the fins are strengthened by long stout spines. In many cases the spines are broad, scimitar-shaped, and provided with deep grooves. The pectoral spines, which are the largest, are articulated to the strong T-shaped coracoids, a peculiarity said to be characteristic of *Acanthodes,* and those genera which with it constitute the *Acanthodidæ.* Although numerous specimens have been discovered, not one has had the anterior parts of the fish well preserved. Generally the head is represented by a mere impression, without any distinct traces of ossified parts; but occasionally a few of the bones are to be seen so crushed and dislocated, that it is difficult to form a correct idea of their relative positions and the general form of the head. The head would seem to have been broad and depressed; the skeleton cartilaginous; and the branchiæ unprotected by any opercular covering. The preservation of the specimens is mainly due to the body having been covered with dermal scales of gonoin. The species varied in size from less than an inch to probably nearly three feet in length; and flourished in the waters which formerly occupied the area of Western Europe from the period of the Old Red Sandstone up to the Permian, or the close of the Palæozoic epoch. *A. Mitchellii* occurs in the lower part of the Old Red Sandstone; *A. coriaceus, A. Peachii,* and *A. pusillus* are found in the middle part of the same formation; and none of the four appear to have been yet discovered out of Scotland. *A. Bronnii* abounds in the nodules of carbonate of iron in the coal measures of Belgium, and is associated with *Amblypterus macropterus,* specimens of which may be gathered in hundreds. *A. sulcatus* occurs in similar nodules in the coal measures near Edinburgh. *A. Wardi,* and probably several other species not yet described, have been found in considerable numbers in the coal measures of North Staffordshire. Lastly, *A. gracilis* is reported from the Permian strata at Klein Neudorf. There are several circumstances connected with these fishes, such as the stratigraphical mode of occurrence, and the scantiness of the dermal armour, especially about the head, as compared with allied genera, which indicate that most probably all the species were inhabitants of fresh waters. The general form of the body, the depressed head, and other features, remind one not a little of the *Silurus glanis,* which dwells at the present day in the rivers of Western Europe. The genus *Silurus* belongs to quite a different order from *Acanthodes;* still it is interesting to find certain external characters possessed by genera which probably differed widely in physiological structure.

(Agassiz, *Poissons Fossiles,* ii. p. 19; Egerton, *Q. J. Geol. Soc.* xxii. p. 468.)

ACANTHOPHIS [E. C. vol. i. cols. 49, 50]. This genus of snakes, which until lately was only represented by Australian species, has recently been discovered in the Isle of Ceram. *A. antarctica* is very common near Sydney, and has been met with in almost every part of Australia. *A. cerastinus* is also Australian, but its range is probably very extensive, since specimens have been discovered in Ceram which differ from those of Australia in colouration only. Dr. Günther regards the Ceramese individuals as forming a variety only of *A. cerastinus.*

ACANTHOPTERYGII [E. C. vol. i. col. 50]. Professor Owen recognises ten orders of fishes, of which the Acanthopterygii constitute the fifth. He divides it into two suborders, viz., the *Pharyngognathi* and *Acanthopteri veri,* and 19 families, most of which are the same as proposed by Cuvier. One of the most recent classifications of the order is that of Dr. Günther, which we subjoin. His definition of the order runs thus:—Part of the rays of the dorsal, anal, and ventral fins not articulated, forming spines. The inferior pharyngeal bones separated. Air bladder, if present, without pneumatic duct. Professor Owen adopts the same definition, but has in addition: endoskeleton ossified; exoskeleton in most as ctenoid scales; ventral fins, in most, beneath or in advance of the pectoral. In Dr. Günther's synopsis (' Catalogue of the Fishes in the British Museum,' vol. 3), the *Acanthopteri veri* are arranged in five great groups.

I.

A soft dorsal and an anal fin. Vent remote from the extremity of the tail and behind the ventral fins, if they are present.

First Division. *Acanthopterygii perciformes.*

Body more or less compressed, elevated or oblong, not elongate. No prominent anal papilla; no superbranchial organ. Dorsal fin, or fins, occupying the greater portion of the back; spinous dorsal well developed, generally with stiff spines, of moderate extent, rather larger than, or as long as the soft; (exceptions—*Rhypticus, Centrarchus sparoides; Hyperoglypha*); the soft anal similar to the soft dorsal, of moderate extent, or rather short; (exceptions—*Haplodactylus,* some species of *Chilodactylus, Latis*). Ventrals thoracic; always present, with one spine and with five or four rays well developed.

I. Ventral one-fifth, rarely one-fourth; no bony stay for the preoperculum. A lateral line.
  A. Lateral line uninterrupted (except in *Ambassis interrupta* and *buruensis*); neither trenchant teeth nor molars; no barbels at the throat. Lower pectoral rays branched.
    a. Teeth on the palate (except in *Prionodes*); ventral fins not scaly . . . . . . *Percidæ.*
    b. Palate toothless (except in some species of *Therapon*); body oblong, or, if elevated, with the ventral fins scaleless . . . . . *Pristipomatidæ.*
    c. Ventral fins scaly; body elevated, or, if oblong, with setiform teeth in the jaws, or villiform bands on the palate . . . . . . *Squamipennes.*
  B. Lateral line interrupted . . . . *Nandidæ.*
  C. A pair of moveable barbels at the throat . *Mullidæ.*
  D. Either a series of trenchant teeth in the jaws or molars on the sides . . . . *Sparidæ.*
  E. Teeth of the jaws confluent into a cutting lamella . . *Hoplognathidæ.*
  F. Lower pectoral rays not branched; neither trenchant teeth nor molars in the jaw . . . *Cirrhitidæ.*
II. A bony stay for the angle of the preoperculum, which is armed, the bone arising from the infraorbital ring . *Scorpænina.*
III. Lateral line absent; a long spinous anal fin *Polycentridæ.*
IV. Ventral fin with an outer and inner spine (1—4—1). . *Teuthididæ.*

Second Division. *Acanth. beryciformes.*

Body compressed, oblong or elevated; head with large muciferous cavities covered with thin skin only. Ventral fins thoracic, with one spine and more than five soft rays; in *Monocentris* with only two. It comprises but one family . . *Berycidæ.*

Third Division. *Acanth. kurtiformes.*

One dorsal fin only, much shorter than the anal, which is long. No superbranchial organ. One family only . . *Kurtidæ.*

Fourth Division. *Acanth. polynemiformes.*

Two rather short dorsal fins, somewhat remote from each other; free filaments at the humeral arch below the pectoral; head with the muciferous system well developed; aspect sciænoid. This also has one family only . . . . *Polynemidæ.*

Fifth Division. *Acanth. sciæniformes.*

The soft dorsal is more, generally much more, developed than the spinous. No pectoral filaments; head with the muciferous system well developed. One family only . . *Sciænidæ.*

Sixth Division. *Acanth. xiphiiformes.*

The upper jaw is produced into a long cuneiform weapon. Contains but one family—*Xiphiidæ.*

Seventh Division. *Acanth. trichiniiformes.*

Body elongate, compressed or band like; cleft of the mouth wide, with several strong teeth in the jaws on the palate. The spinous and soft portions of the dorsal fin and the anal are of nearly equal extent, long, many rayed, sometimes terminating in finlets; caudal fin forked, if present.

There is but one family . . . . . *Trichiniidæ.*

Eighth Division. *Acanth. cotto-scombriformes.*

Spines developed in one of the fins at least. Dorsal fins either continuous or close together; the spinous dorsals, if present, always short, sometimes modified into tentacles or into a suctorial disk; soft dorsal always long, if the spinous is absent (except in *Asphidophoroides*); and similarly developed in the soft dorsal, and both generally much larger than the spinous (except in some species of *Agonus*), and sometimes terminating in finlets. Ventrals thoracic or jugular, if present, never modified into an adhesive apparatus. No prominent anal papilla.

I. One dorsal fin, with several pungent spines anteriorly; one or more bony spines on each side of the tail; teeth compressed, truncated or lobated, closely set in a single series . . . . . *Acronuridæ.*

II. Structure of the skeleton firm; no bony stay for the preoperculum; teeth conical or triangular, if present.

A. The spinous portion of the dorsal present, sometimes rudimentary. Body compressed, oblong or elevated. Vertebræ $\frac{10}{14}$. Sometimes one or two less than 24 . *Carangidæ.*

B. Body elevated with two distinct divisions of the dorsal fin. Vertebræ $\frac{10+x}{14+y}$ . . . . *Cyttina.*

C. Dorsal fin without a distinct spinous portion; head and body compressed. Vertebræ $\frac{10+x}{14+y}$.

a. Toothed processes extend into the œsophagus . . *Stromateina.*

b. No teeth in the œsophagus . . . *Coryphænina.*

D. Two dorsal fins; sometimes finlets; caudalforked. Scales cycloid of moderate size. Vertebræ $\frac{10+x}{14+y}$. *Nomeina.*

E. Two dorsal fins; either finlets, or the spinous dorsal composed of free spines or modified into a suctorial disk, or the ventrals jugular and composed of four rays. Scales none, or very smooth. . *Scombrina.*

F. Body more or less elongate. A spinous dorsal or portion of the dorsal generally distinct, its spines being connected by a membrane; finlets none; caudal not forked; ventrals composed of one spine and five soft rays. Pyloric appendages none, or in small or moderate number.

a. Vertebræ $\frac{10 \text{ or } 10+x}{14+y}$ . . . . *Trachinidæ.*

b. Vertebræ $\frac{10}{14}$ . . . . . . *Malacanthidæ.*

G. The dorsal spines present, composed of a few pungent spines; ventrals jugular $\frac{1}{3}$ . . . *Batrachidæ*

H. The spinous dorsal advanced on the head and more or less modified into tentacles . . *Pediculati.*

III. A bony stay for the angle of the preoperculum, which is armed, the bone arising from the infraorbital ring.

A. Body naked or covered with ordinary scales or incompletely cuirassed with a single series of plate-like scales . . . . *Cottina.*

B. Body completely cuirassed by bony keeled plates or scales . . . . *Cataphracti.*

IV. Skeleton soft . . . . *Cormephoridæ.*

Ninth Division. *Acanth. gobiiformes.*

The spinous dorsal, or spinous portion of the dorsal, is always present (*Lucio-gobius* is an exception), short, either composed of flexible spines, or much less developed than the soft; the soft dorsal and anal of equal extent. Ventrals, thoracic or jugular, if present, composed of one spine, and five, rarely four, soft rays. A prominent anal papilla (except in *Asteropteryx*).

I. Anal spines 0—2; ventral fins.

A. Ventrals entirely modified into a perfect disk adherent to the belly . . . . . . *Discoboli.*

B. Ventrals with the rays always distinct; sometimes united into one fin . . . . *Gobiidæ.*

II. Anal spines six; ventral fins none . . *Oxudescidæ.*

Tenth Division. *Acanth. blenniiformes.*

Body low, subcylindrical or compressed, elongate, rarely oblong, as in *Patuelus.* Dorsal fin very long; the spinous portion of the dorsal, if distinct, is very long, as well developed as the soft, or much more (except in *Zoarces*); sometimes the whole composed of spines only, and more or less long: caudal subtruncated or rounded, if present; ventrals thoracic or jugular, if present.

I. Body band-like: no bony stay for the preoperculum . . *Cepolidæ.*

II. Ventrals jugular, $\frac{1}{5}$ . . . . . *Trichonotidæ.*

III. A bony stay for the angle of the preoperculum, the bone arising from the infraorbital ring . *Heterolepidina.*

IV. Ventrals jugular (except in *Pseudoblennius*), composed of few rays, if present; a prominent anal papilla; and spines none, or in very small number . *Blenniidæ.*

V. Anal spines numerous . . . . *Acanthochinidæ.*

VI. Ventrals none; no prominent anal papilla; body eel-like; numerous free dorsal spines *Mastacentrelidæ.*

Eleventh Division. *Acanth. mugiliformes.*

Two dorsal fins more or less remote from each other; the anterior either short, like the posterior, or composed of feeble spines; ventral fins well developed, $\frac{1}{5}$, abdominal.

I. Dentition strong. Vertebræ 24 . . . *Sphyrænidæ.*

II. Vertebræ $\frac{10+x}{10+y}$. Dentition feeble or of moderate strength. *Atherinidæ.*

III. Dentition feeble. Vertebræ, 24 . . . *Mugilidæ.*

Twelfth Division. *Acanth. gasterosteiformes.*

The spinous dorsal is composed of isolated spines, if present; the ventrals have an abdominal position in consequence of the prolongation of the pubic bones, which are attached to the humeral arch.

I. Ventral joined to the pubic bone, with a spine and with a few rudimentary rays . . . *Gasterosteidæ.*

II. Ventral remote from the pubic bone; with six soft rays . *Fistulariadæ.*

Thirteenth Division. *Acanth. centrisciformes.*

Two dorsal fins, the spinous short, the soft and the anal of moderate extent. Ventral fins truly abdominal, imperfectly developed. . . . . *Centriscidæ.*

Fourteenth Division. *Acanth. gobiesociformes.*

No spinous dorsal; the soft and the anal short or of moderate length; situated on the tail; ventral fins subjugular, $\frac{1}{4}$, with an adhesive apparatus between them entirely absent. Body naked.

I. An adhesive apparatus between the ventrals . *Gobiesocidæ.*

II. Ventrals none . . . . . *Psychrolatidæ.*

Fifteenth Division. *Acanth. chamiformes.*

Body elongate, covered with scales of moderate size; no spine on any of the fins; dorsal and anal long. No superbranchial organ, only a long prominence on the interior surface of the epitympanic bone.

Consists of one family only—*Ophiocephalidæ.*

Sixteenth Division. *Acanth. labyrinthibranchii.*

Body compressed, oblong or elevated, with scales of moderate size. A superbranchial organ in a cavity accessory to that of the gills, for the purpose of retaining water.

I. Dorsal or anal spines present; sometimes in great number. *Labyrinthici.*

II. Neither dorsal nor anal spines . . *Luciocephalidæ.*

II.

Dorsal and anal fins developed. Vent in front of the ventrals.

Only one family . . . . . . *Aphredoderidæ.*

III.

Body riband-shaped with the vent near its extremity; a short anal behind the vent; dorsal as long as the body.

Only one family . . . . *Lophotidæ.*

IV.

Anal absent; caudal rudimentary or not in the longitudinal axis of the fish. Skeleton soft.

Only one family with feeble dentition . *Trachypteridæ.*

V.

A soft dorsal is absent or quite rudimentary; ventrals abdominal, composed of several inarticulated and articulated rays.

Only one family . . . . . . *Notacanthi.*

ACHERONTIA. [SPHINGIDÆ, E. C.]

ACHIRITE, a synonym of Dioptase, a silicate of copper. It was so named after Achir Mamed, a Bucharian merchant.

ACHROITE, a term for the colourless Tourmalines.

ACICULA (Hartmann, 1821), a genus of *Mollusca* belonging to the order *Pulmonata operculata*, or those species which breathe air by means of lungs, and are at the same time provided with an operculum. The shell is almost imperforate, and of a subcylindrical form; the margin of the aperture is somewhat thickened, and forms a thin collar where it meets the previous whorl. The operculum is thin, transparent, and contains but few whorls. As in the other genera belonging to the same family, viz., the *Truncatellidæ*, the proboscis is bilobed; the tentacles are flat and slightly triangular; and the eyes, which are sessile, are situated at the base of the hinder side of the tentacles. The species generally occur in moist or marshy localities, and are mostly restricted to Europe. The known species number about twelve. There is one living British species, viz., *A. fusca*, which is also found in the pliocene strata of Copford, Essex; four or five species occur in France and Spain; two have been met with in Algeria; one in Sicily, and the others occur in Germany. One species lives on leaves in Vanicoro. This genus has some resemblance to *Geomelania*, which is entirely restricted to the New World. The term *Acicula* has been applied to two other genera of *Mollusca*; Blainville used it for what is now called *Achatina;* and Risso for the genus which has since been named *Cæcilianella.*

ACICULITE, or *needle ore*, a native Sulphide of Bismuth. [BISMUTH, E. C.]

ACTINIADÆ. [ACTINOZOA, E. C. S.]

ACTINOPHRYS, a genus belonging to the sub-kingdom *Protozoa*, one form of which, *A. sol*, may be regarded as the most characteristic type of the order *Radiolaria*. The *Actinophrys* is usually spherical in form, and between $\frac{1}{1500}$ and $\frac{1}{650}$ of an inch in diameter. It is closely allied to the *Amœba* [AMŒBA, E. C. S.] both by its structure and mode of feeding, but differs from it in several important particulars. The *Actinophrys* apparently has little or no power of spontaneously moving from place to place. It obtains its food by means of long processes, or pseudopodia radiating from all parts of the body; hence the name, *A. sol*, given to one species. The pseudopodia are long and generally extended. When they are retracted, which happens but rarely, the *Actinophrys* is undistinguishable from an *Amœba* in a similar condition. The way in which active animals are caught and gradually drawn into the body of the *Actinophrys* has been detailed under INFUSORIA, E. C. vol. iii. col. 239.

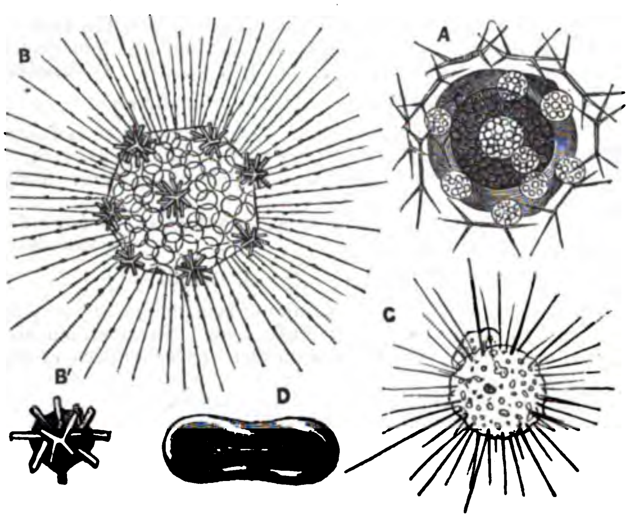


Fig. 1.—C, *Actinophrys sol.* B, B′, *Thalassicolla morum.* A, D, *Thalassicolla punctata.* (After Carpenter.)

The *Actinophrys*, like the *Amœba*, is not quite homogeneous; it consists of a fluid inner portion or *endosarc*, and an outer firmer portion or *ectosarc*, which gradually merge into one another, so that they cannot be separated by any definite boundary line. The endosarc is distinguished by its greater fluidity, and by the coloured granular particles and vacuoles or clear spaces it contains. The pseudopodia arise from the ectosarc alone. When the food is ingested it occupies one or more of the vacuoles, where it is gradually digested, and incorporated with the general substance of the body. The process of digestion occupies some hours, and while it proceeds the mass of the endosarc, with its included vacuoles, keeps up a slow circulatory movement.

There is a well defined contractile vesicle. It consists of a pellucid vesicular spherical body, the central portion of which is occupied by a number of granular particles. Its size varies, but sometimes it is as much as one-third the bulk of the animal itself. It is in constant motion; at one time it may be scarcely visible, but if watched it may be seen to gradually rise until it projects as a rounded prominence beyond the line of the body, as in *fig.* 1, C. When at its utmost expansion it resembles a soap bubble, and is readily distinguished by its transparency. Suddenly it contracts, and resumes its smallest dimensions. This remarkable alternation of slow upheaval and rapid depression has been observed to continue with astonishing regularity for hours together. The fluid with which it is filled is probably propelled into the vacuoles. The vacuoles also expand and contract, but the contractile vesicle is distinguished from them by its constancy of position, its sharper outline, and the rhythmical regularity of its pulsations. Professor Clark says the vacuoles are true cells.

But little is known respecting the methods of reproduction. Frequently, however, an *Actinophrys* may be seen to be so constricted about the middle as to resemble an hour-glass in form; the connecting portion gradually thins until the two halves separate, each with its contractile vesicle. Certain appearances have been noticed by Mr. Carter, which may ultimately prove to be in some way connected with a true sexual process of reproduction. These appearances consist of an aggregation of granules in the vesicular portion of the contractile vesicle, which undergoes successive binary subdivisions, and ultimately breaks up into segments. The segments acquire a globular form, which they retain until the granules of which they are composed are endowed with powers of locomotion, when they separate from each other.

Actinophrys forms the typical genus in the family *Actinophryna*. The other genera differ somewhat from it in structure. Thus in *Trichodiscus* the pseudopodia are arranged in a single zone round the thickest portion of the body, which is spheroidal in form. In *Plagiophrys* they are developed at one portion only, the remainder of the body being enveloped in a flexible membranous lining. In this respect we have an easy transition to *Euglypha* with its flask-shaped test, which in some species is beautifully sculptured.

We may here also notice the families *Acanthometrina*, *Polycystina*, and *Thalassicollina*, which appear to possess the structure of *Actinophrys* with the addition of a siliceous skeleton or framework.

In the *Acanthometrinæ* the body is spherical, and composed of an outer layer or ectosarc, which encloses an inner less tenacious portion, or endosarc. The latter contains a number of yellow globules, like those in *Thalassicolla*, which are turned brown by iodine, black by subsequent treatment with sulphuric acid, and green when treated with hydrochloric acid alone. The rest of the body turns bright yellow under the double action of the iodine and sulphuric acid. In some *Acanthometrinæ* the central portion of the body is occupied by a substance which is bright crimson when viewed with the naked eye, but reddish purple when looked at under the microscope by transmitted light. The skeleton consists of a series of spines regularly arranged about a common centre. They are grooved at the base; the groove gradually passes into a canal, which perforates the remainder of the spine. Some of the pseudopodia issue from the endosarc, traverse the tubular spine and emerge at its apex; others pierce the ectosarc in the spaces between the spines.

The *Polycystinæ* resemble *Actinophrys* in having tapering pseudopodia arranged radially and separated from each other. They are characterised by their beautiful siliceous envelopes, which occur so abundantly in the ooze from the deepest parts of the Atlantic. They have also been found in the Mediterranean, and sparingly in some parts of the South Sea. But the living are far less numerous than the fossil species, which occur in the tertiary formations. Ehrenberg has described nearly 300 forms from a tertiary deposit in the island of Barbadoes; which although ranked as species, it is probable that a more careful examination will prove to be simply varieties of a few species only.

We know but little of the animals to which these shells belong: the sarcode body is believed to occupy the upper portion only of the cavity, the pseudopodia being protruded through the foramina.

The *Thalassicollinæ* include a group of animals found floating passively near the surface of the ocean. Although abundant in most seas, but little attention had been given to them prior to 1851. The few forms known have been divided by Professor Müller into the simple and aggregate. *Thalassicolla morum*, *fig.* 1, B, B′, is an example of the first division, and *Thalassicolla punctata*, *fig.* 1, A D, is an example of the second. In *T. nucleata* there is a spherical central vesicle, an inner fluid portion, and an outer strong and elastic membrane. In the fluid interior are a number of dark granules. Throughout both these parts are numerous vacuoles of various sizes, the larger ones being outermost. Scattered amongst the vacuoles of the inner part are many bright yellow spheres about $\frac{1}{1500}$ inch in diameter. From the surface of the vesicular body delicate fibrils radiate into the outer envelope. Partly embedded in the outer surface of the ectosarc are siliceous spicules much like those in some species of *Tethya*, amongst the sponges. In *T. punctata* (*Sphærozoum punctatum*, Müller) we have an aggregated mass of spheroidal bodies invested in one common membrane, as in *fig.* 1, A. One of the spheroidal bodies is shown on a magnified scale in *fig.* 1, D. It contains a distinct nucleus in the centre, surrounded by dark granules. It is surrounded by siliceous spicules resembling those of *Halichondria*. In the compound as well as in the simple form there are bright yellow spheres diffused generally through the body, fibres radiating from the outer portion of each sphere into the substance of the gelatinous investment in which it is imbedded, and numerous vacuoles. In another form, viz. *Collosphæra Huxleyi*, there are no investing spicules, but the body is enveloped in a transparent siliceous case perforated with numerous apertures.

Professor Müller has grouped the forms here treated of, excluding, however, the *Actinophryna*, under his order *Radiolaria*. He divides them into two sub-classes—1, *Solitaria*, single; and, 2, *Polyzoa*, aggregated. The *Solitaria* includes (1) the *Thalassicollina*, (2) the *Polycystina*, and (3) the *Acanthometra;* the *Polyzoa* include (1) the *Sphærozomidæ*, and (2) the *Collosphæridæ*. The term *Polyzoa* has already been employed to designate a group of molluscoidous animals.

Dr. Wallich has also proposed a classification of this group in the 'Quarterly Journal of Microscopical Science,' 1865-6.

The group of *Radiolaria* has only been known by marine species; but Dr. Focke has recently discovered a few species in bog-waters. In general structure they appear to come near the *Thalassicollina*.

(Carpenter, *Introduction to the Study of the Foraminifera;* Greene, *Manual of the Protozoa.*)

ACTINOZOA. This class is now represented by nearly 3000 reputed species, while the allied class of *Hydrozoa* contains not many more than 500 species, and certainly less than 1000. Accompanying this disparity in numbers, it is noticeable that the *Hydrozoa* present wider and more numerous modifications of their archetypal plan of structure than do the *Actinozoa*. It is also noticeable that the *Hydrozoa* have a simpler organisation than the *Actinozoa*, and that the former are, generally speaking, smaller than the latter.

A full account of the typical plan of a *Hydrozoon* is given under Hydrozoa, E. C. S., but may be shortly re-stated here.

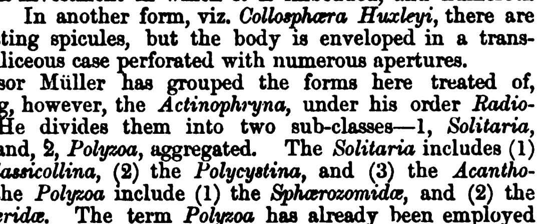


Fig. 1.—A, Longitudinal section of a typical *Hydrozoon*. B, Longitudinal section of a typical *Actinozoon*. (From Greene's *Cœlenterata*.)

It is a triple-walled sac, having a more or less cylindrical columnar form, which is fixed by its base or *proximal* end, while the opposite or *distal* end terminates in an aperture mounted on a conical projection, which is, in its turn, surrounded by a circle of tentacles. The *Actinozoon* may be described in essentially the same terms, with the difference that the *distal* extremity is composed of an almost flat disk, near the centre of which is a lineal aperture surrounded by one, or, as is usually the case, more than one, row of tentacles, which aperture leads into the general body, or *somatic* cavity, through a cylinder formed by a membrane suspended from the margin of the mouth. This difference is expressed in the accompanying diagrammatic figures, which, however, represent two walls only, viz. the outer or *ectoderm*, and the inner or *endoderm*.

The two classes here contrasted together form the sub-kingdom *Cœlenterata*, the relationship between which is thus represented by Greene:—

Sub-kingdom Cœlenterata. Animals whose alimentary canal freely communicates with the somatic cavity. Substance of the body made up of two foundation members, an outer or ectoderm, and an inner or endoderm, which correspond in mode of growth with the primitive layers of the germ.

No distinct neural and hæmal regions. A nervous system absent in most. Peculiar urticating organ or thread-cells usually present.

CLASS I.—HYDROZOA.	CLASS II.—ACTINOZOA.
Cœlenterata in which the wall of the digestive sac is not separated from that of the somatic cavity, and the reproductive organs are external.	*Cœlenterata* in which the wall of the digestive sac is separated from that of the somatic cavity by an intervening space, subdivided into chambers by a series of vertical partitions, on the faces of which the reproductive organs are developed.

This quotation is given as it represents the general opinion at the present time, but we believe future researches will not support the accuracy of the distinction here laid down. Setting aside the question as to whether the sacs be double or triple-walled, as referring equally to both groups, and as being a matter of opinion, and not of fact, or to what is to be called a foundation membrane, we will confine our attention to two points; (1), the separation or nonseparation of the digestive sac from the somatic cavity; and (2), the position of the reproductive organs. In both cases we may mention the difference does not depend upon observation, but upon the way in which what is seen is to be interpreted. If *Hydra* and *Actinia* are taken as types, and the distinction between them be regarded as the distinction between the classes they represent, little or nothing can be said against the above definitions. But if *Actinia* be contrasted with some more highly developed representative of its class than *Hydra*, the terms of the above definition will require essential alterations. We cannot say what the definitions should be, but probably the difference in the position of the digestive sac might be expressed by saying that in the *Hydrozoa* it is placed on the distal side of the *cœnosarcal* cavity, while in the *Actinozoa* it is suspended in and surrounded by a cavity homologous with the *cœnosarcal* cavity of the *Hydrozoa*. As regards the reproductive organs, they are internally situated in both classes, if by reproductive organs be meant ovaries and spermaries as in the jelly fishes or *Medusidæ*, and sea anemones. The so-called reproductive organs of the zooids of the *Hydrozoa* are polypites specially modified for carrying on the continuation of the species, and the ovaries and spermaries are situated within their walls; so that the reproductive organs are as essentially internal in the one class as in the other. In *Hydra*, however, it is true that the ovaries and spermaries are apparently external; but until we know more as to the reproduction of this genus it would be premature to decide upon the real morphological position of the reproductive organs, or to consider this genus as the type of its class. Probably the mode of development would be a good basis of distinction, for in the *Hydrozoa* it generally consists of an egg, a polypite, and a medusa, which last reproduces eggs; while in the *Actinozoa* the egg grows into a *polype* and the *polype* produces forms like itself, or other polypes, by which eggs are produced. These points, however, will be more fully considered under Hydrozoa, E. C. S., and the articles referred to below.

In the Cyclopædia the class *Actinozoa* is treated of under Actiniadæ, Alcyonidæ, Beroe, Callianira, Calymma, Gorgonia, Polypifera, Madrephylliœa, Madreporea, Mille-

PORIDÆ, and ZOANTHARIA. The additional remarks on these will be thus distributed in the Supplement :—

Actiniadæ, Polypifera, Madrephylliæa, Madreporea, Milleporidæ, and *Zoantharia,* under ACTINOZOA, E. C. S.; *Alcyonidæ,* and *Gorgonia,* under ALCYONARIA, E. C. S.; *Beroe, Callianira, Calymma,* under CTENOPHORA, E. C. S.

General Plan and Structure of the Zoantharia.—As the classification of the *Actinozoa* is not so satisfactory as might be wished, it will be as well to give the generally accepted definitions of the orders before entering into details respecting the structure of this group. The definitions as given by Greene in his 'Manual of the Cœlenterata,' run thus :—

Zoantharia:—*Actinozoa* in which the tentacles are simple or variously modified, in general numerous, and, together with the mesenteries, disposed in multiples of five or six. Corallum absent or sclerobasic, in most sclerodermic, the septa of each corallite following the numerical law of the soft parts.

Alcyonaria:—*Actinozoa* in which each polype is furnished with eight pinnated fringed tentacles. Mesenteries and somatic chambers, in number some multiple of four. Corallum sclerobasic or spicular, rarely thecal, and never presenting traces of septa.

Ctenophora:—Transparent, oceanic, delicate, gelatinous *Actinozoa,* swimming by means of ctenophores or parallel rows of cilia disposed in comb-like plates. No corallum.

A definition is also given of the *Rugosa,* to which the above-cited author assigns an ordinal rank; but as it is very doubtful if the group is entitled to be so considered, and as the definition embodies a mis-statement, we have preferred to leave it out.

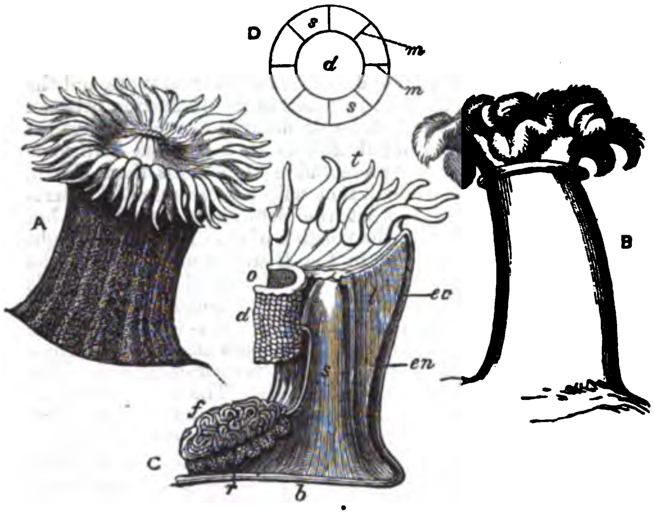


Fig. 2.—A, *Sagartia parasitica.* B, *Actinoloba dianthus.* C, Segment of an *Actinia; t,* tentacles; *o,* polype-mouth; *d,* digestive sac; *l,* muscular layer; *ec.* ectoderm; *en.* endoderm; *s.* mesentery; *b.* base; *r.* reproductive organs; *f,* craspeda. D, Ideal, horisontal section of an alcyonarian, showing the same general arrangement as in an *Actinia; d,* digestive sac; *m,* mesenteries; *s,* chambers.

The typical form of this order, and, indeed, of the *Actinozoa* in general, may be represented by some of our common sea-anemones, such as *Tealia crassicornis* (a description of which has already been given in the article *Actiniadæ,* E. C., under the name *Actinia coriacea*), or *Actinia mesembryanthemum,* or *Actinoloba dianthus,* or a *Sagartia.* In all these cases we have a soft fleshy mass, which is generally fixed to a stone or rock, and is capable of undergoing considerable modifications of form; these modifications being produced by variations in the state of the muscular system. Thus at one time it may appear as a smooth hemispherical button-shaped mass; while at another it is a finely proportioned column, surmounted by a flattish top, which is surrounded by a fringe of radiately disposed conical processes, or tentacles, as in *Sagartia parasitica* (*fig.* 2, A). The attached end is called the *base,* the portion between it and the margin of the disk is the *column,* and the upper face the *disk.* In the centre of the disk is an aperture, generally seated on a slight prominence, which forms the *mouth* or *actinostome.* The space between the tentacles and the *actinostome,* or polype-mouth, is known as the *peristomial space,* and is generally marked by white lines, which indicate the uppermost edges of certain laminæ, or membranous layers, about which we shall have more to say when we come to consider the internal structure of the animal. In most British species, the margin of the disk is formed by an annular projection or parapet, as in *fig.* 2, B, between which and the tentacles there is a groove or *fosse.* The outer wall of the column, or ectoderm, consists of three layers; the first and outermost is formed of epithelial ciliated cells, which being constantly thrown off, give rise to the thick coat of mucus so frequently found enveloping these creatures in aquaria; next comes a granular layer, having embedded in it the urticating organs, of which more anon; and the third is formed of the pigment cells to which the gorgeous and varied tints of these animals are due. Below the endoderm comes the well-developed muscular system (*fig.* 2, *C, l*), which is formed of (1), an outer layer of transverse fibres; (2), an inner one composed of fibres arranged longitudinally; and (3), of a series of thin plates, composed of fibres arranged transversely and longitudinally, the outer edges of which are inserted throughout the body-wall, while the inner edges project more or less into the somatic cavity. These plates form mesenteries, or partitions, *fig.* 2, *D, m,* which divide the somatic cavity into a series of imperfect chambers or *loculi.* The white lines in the peristomial space indicate the junctions of the edge of these septa with the under side of the disk. It is by the extension of this system of muscles, combined with the distension of the interior with water, that the firmness of these animals, when expanded, is obtained. Recurring again to the body-wall, we find that at the summit of the column, and just below the point of origin of the tentacles, there is in many species a ridge, which ridge (*fig.* 2, B) is a muscular cord acting as a sphincter, whereby the disk and tentacles may be covered over. The space between this covering membrane and the disk has been called the *prebuccal cavity.* The external surface of the column is smooth in some species, but in others it is covered with warts or tubercles, which are said to be formed by corrugation in the outer layer of muscles. Thus Gosse states that in certain species of *Sagartia* the muscular tissue in contraction corrugates into reticulate or honey-comb like patterns, inclosing shallow cells of much regularity. It is, he believes, these cells with perpendicular walls of muscular tissue that constitute the sucking warts, by means of which fragments of shell or gravel are grasped and retained with considerable force. "If this exposition is correct, all the corrugated cells are capable of becoming suckers at the will of the animal; but, in fact, only a few are so used at one time. The cells (in *S. nivea,* and *S. miniata*) are about ·014 inch in depth and longitudinal diameter, while their transverse diameter may average about ·084 inch." In the *Bunodidæ* the cells are larger, and have thicker walls. Next beneath the muscular system is a third layer, known as the *endoderm.* It lines the whole of the interior of the somatic cavity, extending to the tips of the tentacles, and covering both faces of the mesenteries. Wherever the inner edge of the mesentery is free, the endodermal layer from each face is continued forward, and the space between each pair of layers encloses the reproductive elements; they then unite to form a long cord or *craspedum.* The inner surface of the endoderm is crowded with vibratile cilia, by means of which the circulation of the fluids in the somatic cavity is promoted; this circulation is considered by some to form its alimentary-respiratory apparatus.

The polype-mouth (actinostome) is generally an elongated aperture, which leads into a short flattened sac, opening by its proximal end into the general cavity of the body. This sac is the digestive cavity, the walls of which are formed of its endodermal, muscular, and ectodermal layers. The inner surface is corrugated with a series of deeply impressed grooves, and the lower edge hangs freely in the somatic cavity like a curtain. According to some of the earlier observers, the lower edge is thickened, and capable of acting as a sphincter muscle, but later investigations have not confirmed these statements. The food passes into the digestive sac, and is retained there for hours, until the assimilable portions have been separated, and passed into the somatic cavity. It is then rejected through the polype-mouth. The digestive sac is kept in position by some of the mesenteries, the edges of which are united with it. In most species there is a groove or tubercle (the *gonidial* groove) at one or both angles of the polype-mouth; it forms the aperture to a tube which traverses the whole length of the wall of the digestive cavity. Little or nothing is known as to what its function may be. When the eggs are discharged, they frequently make their exit by the gonidial grooves; but there is nothing to show that this is their special function. On the contrary, it happens that the eggs are as frequently discharged through the mouth, while there are some genera which have but one gonidial groove, and others which have none at all. The walls of the digestive cavity are generally lined with coloured pigment cells, which it has been suggested may represent a rudimentary liver.

Having thus roughly indicated the relative positions and names of the principal parts, the way is cleared for appreciating some of the minute details. The general plan of structure is, as may be seen, radial, but in some groups it is so modified that the plan is essentially bilateral. Lowly creatures though they be, they are endowed with a sense of touch delicate enough to feel the minutest visible speck which comes in contact with their tentacles, and to discriminate in most cases between substances which are or are not adapted for nourishment. If the substance is not suitable, it is allowed to fall away by inclining the tentacle or body; but if suitable, thousands of darts are buried in it to retain it, and the muscles are brought into action to convey it to the oral aperture, through which it is passed into the digestive cavity; from there the digestive fluid with the alimentary portions of the food in solution is passed into the somatic cavity, and carried over every part of the interior surface of the mesenteries, chambers, and tentacles by means of vibrating cilia. They possess the faculties of secretion, excretion, respiration, and respond to the condition of things around them, spreading out their disk and tentacles in evident enjoyment when these are congenial, and retracting themselves when the conditions are unfavourable. The continuance of their kind is provided for either by the development of portions of their tissue, which in some cases is retained in connection with the parent, while in others it is separated, or by the longitudinal fission of the body into two parts, or by means of reproductive organs which develope spermaries and ovaries. This is not a very high grade of structure, but it is evidently superior to that possessed by the *Protozoa*, amongst the lowest of which the functions of life are carried on by one or two layers only, with but feeble traces of the specialisation of the different functions in different organs. In the protozoon, most of the vital actions are carried on by all parts alike; but in the *Actinozoa* we have a greater number of distinguishable parts, each of which has a distinct duty to perform. The actinozoon possesses but little more complexity of organisation than the hydrozoon. Both have organs of the same kind; but in the actinozoon they are somewhat more highly developed, and have a somewhat different arrangement than in the hydrozoon. In the former there is a more powerful and more varied muscular system, a greater degree of sensitiveness, and in both the digestive cavity is distinct from the general body cavity; but in the hydrozoon it is situated differently from that of the actinozoon, as already pointed out.

In the *Zoantharia* the repetitive parts are generally developed in multiples of five or six; and this numerical law prevails in the development of the tentacles, the mesenteries, and the chambers. The mesenteries, as we have said, are their muscular partitions; they vary in size according to the order of their development. The mesenteries commence their growth from the distal extremity towards the base. First of all, six grow simultaneously, and generally at equal distances apart; in some the two opposite each end of the oral aperture are rather more forward than the remaining four. When fully formed they are attached by one edge to the whole height of the body wall, and by the other to the full length of the digestive cavity. Below the lower limit of this cavity the inner edge of the mesentery is arched outwardly, the proximal portion of it curving inwards to the centre of the base. These mesenteries are termed *primary*, and the spaces between them are designated primary loculi. The next group, generally six in number, appear half way between those of the first; but although inserted throughout the whole height of the column wall, they do not reach so far down on the stomach wall as the first group, and do not extend so far towards the middle of the base. The spaces between these are called *secondary* chambers. The third or tertiary group of mesenteries are usually twelve in number, and form the partitions to the tertiary chambers. In each succeeding group, which are for the most part twelve, the size becomes less and less, and according to their order they extend less far towards the digestive cavity and centre of the base. In many genera the mesenteries secrete earthy or calcareous matter, which forms the stony partitions, or *septa*. These are developed in the same way, and according to the same numerical law as the mesenteries; and since they are trustworthy guides to one important feature in the structure of the soft parts, they are of high interest to the palæontologist, whose knowledge is confined to the hard parts in all the extinct species. The following diagrammatic cut (*fig.* 3) represents a section of some of the septa of the *Zoantharia*. The radii indicate the septa; the numbers placed against them at the circumference, those which develop simultaneously, as also their order of succession; the Roman numerals, with the concentric rings corresponding with them, are intended as guides, the numerals having the same signification as the ordinary figures. All the septa which grow simultaneously, that is, all those situated on the same concentric ring in the diagram, are said to be of the same *order;* and as there are 17 circles, 17 orders of septa are indicated in the cut; while those which divide chambers having the same breadth at the column wall belong to the same *cycle*. Thus, on referring to the figure, it will be seen that the septa of the first order meet at the centre; those of the second order, six in number, if all were drawn, do not extend so far, and as they separate chambers similar in size, they form the second cycle of septa. The third order comprises 12 septa, and these also form the third cycle. The fourth, and, indeed, all subsequent orders, comprise 12 septa, and hence only half the quaternary chambers are bisected; the other half are divided by the next order of septa; so that the fourth cycle comprises septa of the fourth and fifth orders. The fifth cycle includes the sixth, seventh, eighth, and ninth orders; the ninth cycle all the orders from the tenth to the seventeenth. All the chambers having the same circumferential breadth are said to be *similar*, while those which are bounded by septa of corresponding orders are of the same *expression*. Thus the chamber denoted by 1—10 is similar to that indicated by 10—6 or 8—12; but is of the same expression as the chamber 10—1. On looking at the figure it will be seen that the first three orders are the same as the first three cycles; beyond which point there is a divergence, as two or more cycles correspond to one order. After the third cycle there are more chambers than the number of septa forming each cycle, so that the septa can appear in some only of the similar chambers, but which will develop them first is also regulated by a law which may be expressed numerically. Physiologically the new septa appear at the intermediate points which have been longest at rest. Numerically they appear in the chambers, the two terms of whose expression yield the smallest total, or where chambers having different expressions yield the same result, they appear in those having the lowest term. This will be manifest on tracing the order of development as drawn in fig. 3. If an eighteenth cycle of septa were developed, they would appear in the chambers having the expression 1—10, and they might be looked for in those with the expression 6—14 before those denoted by 8—12. It is on these grounds that Milne-Edwards has formed his five rules of septal development, which are here given:—

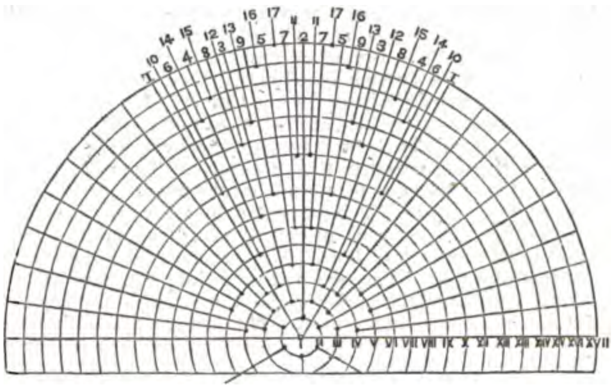

16 17 11 11 17 16
14 15 12 13 13 12 15 14
10 10
I 6 4 8 3 9 5 7 2 7 5 9 3 8 4 6 I
II III IV V VI VII VIII IX X XI XII XIII XIV XV XVI XVII

Fig. 3. Diagram of the septa in *Zoantharia*.

1. The formation of new septa takes place simultaneously in all loculi having the same expression.
2. The formation of septa takes place successively in loculi having a different expression.
3. The order of succession of the septa is determined in the first place by the age of the cycle to which they belong, and those of a new cycle do not commence to be formed till the development of the preceding cycle is complete.
4. Among loculi of the same cycle having different expressions the evidence in the formation of new septa is determined by the inferiority of the sum of the two terms of this expression.
5. Among loculi of the same cycle having different expressions, but which yield the same sum by the addition of the two terms, the order of appearance of the septa is determined by the relations which exist between the lowest terms of the three expressions, the new septa being formed first where the lowest term occurs.

It is only in a portion of this order that the hard septa are developed in the endoderm; in another portion hard parts are developed in the ectoderm or outer layer; while in yet a third no hard parts are formed. Great importance has been attached to these characters in the classification of these creatures, as in Milne-Edwards' scheme, who groups the families in three sub-orders, known as *Zoantharia malacodermata*, or the soft-skinned group; *Z. sclerobasica*, or the group having the hard parts developed in the outermost wall; and *Z. sclerodermata*, or the hard-skinned group, which deposit earthy salts in the inner tissues.

The sclerobasis has been met with only in the families *Antipathidæ* and *Hyalochætidæ*, and it is doubtful if either belong to the *Zoantharia*. The former is sometimes grouped with the *Alcyonaria*, and the latter is based partly upon specimens which have been ingeniously built up by the Chinese from the siliceous fibres of sponges and the dried animals of certain corals, and partly upon sponges partially covered by parasitical coral-like animals. It is far better developed in the *Alcyonaria*. The sclerodermic corallum presents every degree of development. In its most rudimentary condition it is represented by a few spicules which are somewhat cartilaginous in consistence, but contain a large proportion of some salt of lime. These are termed *dermosclerites* by Milne-Edwards. There are two varieties; viz., such as are fusiform, with a nodular surface; and those which are irregular groupings of nodules and spines. The last are generally more highly calcareous than the former, and frequently present indications of a hexapartite arrangement. In other species the spicules are more numerous, and coalesce to form continuous layers. In this connected condition it is termed *sclerenchyme*, or coral tissue, and its texture, depending mainly upon the paucity or abundance of the sclerites, has been employed in characterising certain groups of families. Thus in the *Perforata*, the texture varies from spongy and reticulate to porous and granular; while in the *Aporosa* it is firm and compact. The sclerenchyme again is more fully developed in certain genera than in others. Thus in some the calcareous matter is deposited in the body wall forming the *theca*, in the mesenteries forming the *septa*, and in the horizontal basal portion of the polype forming the *tabulæ*. The septa sometimes have calcareous horizontal partitions, or *dissepiments*, extending more or less from their sides, which resemble imperfect tabulæ, except that the tabulæ grow from the theca, whereas the dissepiments grow from the septa. The sides of the septa also support, in some cases, long narrow processes extending like transverse props across the loculi, which are technically termed *synapticulæ*. The primary septa may extend to the centre of the corallum, or as far only as the filled-up central portion, or *columella*, or may stop short of the *columella*. In the last condition the septa form upright pillars, and are then termed *pali*. In addition to these parts others may be developed outside the *theca*. Thus its outer surface may be marked by longitudinal ridges corresponding in position to the septa (*costæ*), while the sides of these may develop plate-like processes, or *exotheca*, analogous to the dissepiments between the septa. The corallites are occasionally isolated and distinct, but more frequently they give rise to other corallites by a process of budding, the new corallites retaining their connection with the parent polype. The forms produced by this budding vary with each group, but are considered by some to be sufficiently constant and uniform in each to be used as a basis of classification. The corallites are frequently massed together and embedded in a connecting tissue or *cœnenchyme* (the name for the hard parts deposited in the *cœnosarc*), but there are many compact masses in which the cœnenchyme is absent, and the thecæ are in immediate apposition. The variety of external form will be noticed when an outline is given of Ludwig's new classification of the *Zoantharia*.

The tentacles are always hollow appendages in free communication with the somatic cavity; and generally they are of a conical form, more or less curved, and gradually tapering towards the extremity. Sometimes they are short, and reduced to mere tubercles; at others they are long, of a highly sensitive nature, and in constant motion. They appear to follow the same law of development as the mesenteries, so that usually there is one tentacle for each interseptal chamber. In some genera, such as *Corynactis* and *Caryophyllia*, the extremity is terminated by a globose knob. The extremity is, in many, probably most genera, perforated, and the aperture can be closed or opened at the will of the animal. When suddenly alarmed, it frequently happens that the tentacles contract with great violence, discharging the nutrient fluid which distends their tissues through the apertures at their points. The force of ejection is such, that the fluid will strike with considerable force against the face of a person who stoops with the intention of removing them from the rock. In many of the tropical forms some of the marginal tentacles have a compound dendritiform character, frequently reminding one of the tentacles in the *Echinodermata*. It is also in tropical species that open tubes or apertures occur on the peristomial space, through which long ribands, or *acontia*, are discharged. These organs, however, are more usually protruded through pores in some part of the column wall. According to Duchassaing and Michelotti the species in which these acontia are best developed employ them almost exclusively for capturing food, the tentacles being seldom used for the purpose. The tentacles and the white threads used for capturing prey are crowded with a multitude of small oval transparent vesicles, which emit a dart attached to a long thread; these cells are called *cnidæ*, and, as Mr. Gosse has given a very complete account of them, we will append his description almost in his own words. They are found in various parts of the body; as, for example, in the tentacles, in the marginal spherules of certain species, in the corrugated integument that surrounds the mouth, in the walls of the stomach, and in the epidermic masses that are constantly formed under the stimulus of irritation; but they are more especially abundant in the *craspeda* and *acontium*. The craspeda are the marginal thickened edges of the innermost extension of the two laminæ of the mesentery. They are probably to be found in all the *Zoantharia*, and generally in great abundance. In *Tealia crassicornis*, for example, they constitute an inextricable tangle of white frilled cords, seen everywhere below and behind the stomach, and protruding through every wound in the integuments. When the craspedum is pressed it exhibits (1), a clear, colourless, highly refracting sarcode, which draws out into strings and long-tailed drops, like an oil on a wet surface; (2), minute scattered granules very irregular in shape; (3), yellow granules of an irregularly ovate form grouped closely in mulberry-like masses; and (4), cnidæ. By pressure the last are seen to be arranged along the edge of the craspedum, with their long axes set with the breadth of the cord, and the points from which the darts issue just beneath the surface of the tissue. Certain species of *Zoantharia* are able to shoot forth from various parts of their body a number of thin flexible filaments, usually of an opaque white, but sometimes of a brilliant lilac tint. In *Sagartia parasitica*, *S. miniata* and *Adamsia palliata*, the threads are so profuse as to form tangled masses like tufts of sewing cotton. On watching one of these threads the observer will see it gradually re-enter the body through the same orifice by which it protruded. In *S. parasitica* these filaments, or *acontia*, extend as much as six inches from the body. Yet in a few minutes the whole has disappeared. It is gradually corrugated into smaller irregular coils at the end which is attached to the animal; and

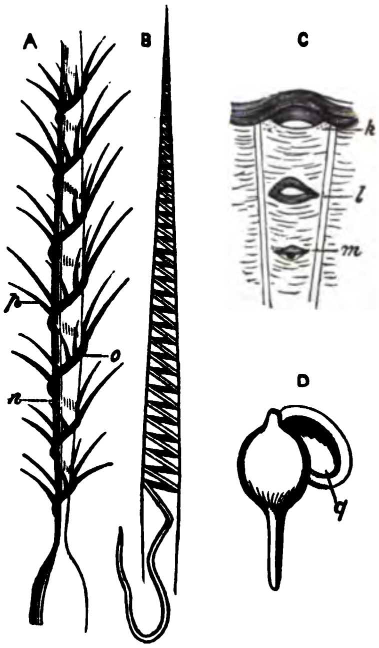


Fig. 4.—A, B, D, Various forms of *cnidæ* or thread-cells. C, *Cinclides*. (Gosse's "*Actinologia Britannica*.")

these little coils are one after another sucked in through an imperceptible orifice. *Acontia* are less common than *craspeda;* for the former are only recorded as occurring in the *Sagartiadæ* and *Bunodidæ*. In *Sagartia bellis* they spring from the mesenteries that carry the craspeda, generally two acontia from each mesentery; and most frequently in pairs. They are inserted at all parts of the length of the mesentery. The *acontium* is a flat narrow ribbon with involute edges which can be approximated so as to form a tube. Like the craspedum, of which it seems to be a specially modified form, the surface is mostly ciliated; these cilia create a strong current of water, and when fragments of the acontium are detached the action of the cilia propels them through the water. The acontium presents the appearance of a clear sarcode, which shows no traces of fibres even under a magnifying power of 800 linear; nevertheless it is endowed with well marked powers of contractility. When subjected to pressure it behaves similarly to the craspedum. The acontia are emitted through special orifices in the columnar wall termed *cinclides*. Thus in *Sagartia* there are a number of foramina which connect the interseptal chambers with the surrounding water. In *fig.* 4, C, three of these are shown in different states; in *m* the lids are wholly closed, in *l* slightly open, and in *k* wide open. The dimensions of the apertures vary with the species, with the size of the individual, and with the extent to which they are opened; the measurements noticed in several specimens of *Actinoloba dianthus, Sagartia nivea, S. bellis*, varied from the $\frac{1}{275}$th to the $\frac{1}{55}$th of an inch. The apertures are usually covered with an exceedingly thin film, probably formed of the mucus which is constantly forming on the surfaces of these creatures. Mr. Gosse records the following observations showing that the cinclides are the special orifices through which the acontia are protruded. "In a rather large *S.* [*Actinoloba*] *dianthus*, somewhat distended, placed in a glass vessel between my eye and the sun, I saw, with great distinctness, by the aid of a pocket lens, many acontia protruded from the cinclides, and many more of the latter widely open. The acontia, in some cases, did not so accurately fill the orifice but that a bright light (or a darkness, according as the sun was exactly opposite or not) was seen, partially bordering the issue of the thread, while the thickened rim of the cinclis surrounded all. The appearance of the orifices whence the acontia issued was that of a tubercle or wart, and the same appearance I have repeatedly marked in examples observed on the stage of the microscope: namely, that of a perforate pimple or short columnar tube. This was clearly manifest, when the animal, slowly swaying to and fro, brought the sides of the cinclis into partial perspective. On another occasion I witnessed the actual issue of the acontia from the cinclides. I was watching, under a low power of the microscope, a specimen of *S. nivea*, while, by touching its body rudely, I provoked it to emit its missile filaments. Presently they burst out with force, not all at once, but some here and there, then more, and yet more, on the repeated contractions of the corrugating walls of the body. Occasionally the free extremity of a filament would appear, but more frequently the bight of a bent one, and very often I saw two or even three issue from the same cinclis. The successive contractions of the animal under irritation caused the acontia already protruded to lengthen with each fresh impetus, the bights still streaming out in long loops, till perhaps the free end would be liberated, and it would be a loop no longer; and sometimes a new thread would shoot from a cinclis whence one or two long ones were stretching already; while, as often, the new-comers would force open new cinclides for themselves. The suddenness and explosive force with which they burst out appeared to indicate a resistance which was at length overcome: perhaps—in part at least—due to the epithelial film above-mentioned, or to an actual epiderm, which, though often ruptured, has ever, with the aptitude to heal common to these lowly structures, the power of quickly uniting again. It appeared to me manifest, from this and other similar observations, that no such arrangement exists as that which I had fancied; that a definite cinclis is assigned to a definite acontium, or pair of acontia, and that the extremity of the latter is guided to the former, with unerring accuracy, by some internal mechanism, whenever the exercise of the defensive faculty is desired. What I judge to be the true state of the case is as follows: The acontia, fastened by one end to the septa or their mesenteries, lie, while at rest, irregularly coiled up along the narrow interseptal fossæ. The outer walls of these fossæ are pierced with the cinclides. When the animal is irritated, it immediately contracts; the water contained in the visceral cavity finds vent at these natural orifices, and the forcible currents carry with them the acontia, each through that cinclis that happens to lie nearest to it. The frequency with which a loop is forced out shows that the issue is the result of a merely mechanical action; which is, however, not the less worthy of our admiration because of the simplicity of the contrivance, nor the less manifestly the result of Divine wisdom working to a given end by perfectly adequate means. The ejected acontia, loaded with their deadly cnidæ in every part of their length, carry abroad their fatal powers not the less surely than if each had been provided with a proper tube leading from its free extremity to the nearest cinclis." The cnidæ vary in their structure, and may be assigned to four distinct forms, to which Gosse gives the names of (1), chambered, (2) tangled, (3) spiral, (4) globate. The chambered cnidæ are those most generally found in this order. In *Caryophyllia Smithii* they seem to form almost the whole of the globular head of the tentacles, and they are also very abundant in the craspeda. As they are larger in this than in most other species, Gosse adopts them as a standard for description. They are transparent colourless vesicles of a lengthened ovate form, and with one end much larger than the other (*fig.* 5). In the larger end may be seen a narrow fusiform chamber tapering in both directions: the point at the larger end merges into the walls of the cnida, while the opposite extremity, after tapering to a certain point, again dilates into a funnel-shaped portion, beyond which it continues as a slender cord coiled up in numerous folds and filling the whole of the narrow end of the cnida. When the tissues containing the cnidæ are subjected to pressure the contents of the cnidæ are discharged sometimes rapidly and sometimes slowly. Just before the emergence of the thread a minute protrusion appears at the larger end. The thread generally increases slowly and gradually in length until the emerged portion is about twice as long as the thread is wide, when it generally darts forward suddenly. At this instant Gosse states he has in many cases heard a distinct crack. The thread is technically termed the *ecthoræum* (*fig.* 4, A, *n*); when fully extended its length varies from about twice, as in most species of *Sagartia*, to thirty or even forty times the length of the cnidæ. The ecthoræa of chambered cnidæ are always furnished with a peculiar armature. The basal portion is slightly swollen for a short distance, beyond which it is rapidly attenuated for another short distance, the remainder of its length being exceedingly slender and of equal width throughout. In the short ecthoræa of *Sagartia* there is no attenuated portion. It is chiefly upon the swollen basal portion that occur the spiral bands, to which Gosse gives the name of *strebla* (*fig.* 4, A, *o*). The number of bands, the number of turns made by each band, and the angle formed by them with the axis of the ecthoræum, vary in different species. In *Tealia crassicornis*, the screw or strebla is formed of a single band having an inclination of 45° to the axis, and becoming invisible at the seventh turn. In *Sagartia parasitica* the screw is formed by two equidistant bands, each of which makes six turns; they are inclined at an angle of 70° from the axis of the ecthoræum. In *Caryophyllia* the screw is composed of three bands, with ten revolutions each, and with an inclination of 40° from the axis. These bands support a series of firm bristles, which have a broad basis, and taper to a point. These bristles, or *pterygia*, are also indicated by *p* in *fig.* 4, A. Their number varies within slight limits: thus, in *Tealia crassicornis* there appear to be eight in each whorl, while in *Sagartia parasitica, Corynactis viridis*, and other species, there are twelve. The tangled cnida is found in most species associated with the chambered variety. In *Sagartia* it is comparatively rare, while in *Actinia* and *Anthea* it appears to be the only form. It is well seen in *Corynactis viridis*, in which species the shape is a perfect oval. The interior is filled with a long thread, which is generally more confusedly coiled than in the chambered cnidæ. It is probable that the tangled cnidæ also possess a screw, although the minuteness of the parts prevents this point being satisfactorily determined. The base of the thread presents the same serrated appearance under high powers which is perceived round the base of the thread of the chambered cnidæ under lower magnifying powers. The spiral cnidæ are met with in a few

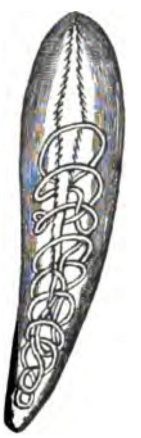


Fig. 5.—*Cnidæ* or stinging cells of *Caryophyllia Smithii*. (Gosse.)

species, such as *Sagartia parasitica*, *Tealia crassicornis*, *Cerianthus Lloydii*, &c. They are highly elongated, and, from the extreme tenuity of their walls, appear to be composed simply of a thread coiled in a close regular spiral; they have a general resemblance to a multispiral shell, such as is frequently possessed by species of the families *Cerithiadæ* or *Turritellidæ* (*fig.* 4, B). The globate cnidæ (*fig.* 4, D) occur in the acontia of *Sagartia parasitica*, and are apparently filled with a fluid having a different refractive power from that of the tissue in which they are embedded. No thread has been detected in them, and it is possible that their function is different from the cnidæ having ecthoræa. Mr. Gosse expresses his general views on the cnidæ in the following terms:—The emission of the ecthoræum is a process of distinct eversion. This thread is not a solid, but a tubular prolongation of the walls of the cnidæ turned in, during its primal condition, like a finger of a glove drawn into the cavity. In the discharge of the ecthoræum of the tangled cnidæ, it frequently runs out, not in a direct line, but in a spiral form; whenever this is the case, each band of the spire is made, and stereotyped, so to speak, in succession, while the tips go on lengthening; the tip only progresses, the whole of the portion actually discharged remains perfectly fixed, which could not be on any other supposition than that of evolution. In the discharge of the chambered kind, the ventricose or basal portion first appears; the lower barbs fly out before the upper ones, and all are fully expanded before the attenuated portion begins to lengthen. This, again, is consistent only with the fact of the evolution of the whole. On several occasions of observation on the chambered cnidæ of *Caryophyllia*, I have actually seen the unevolved portion of the ecthoræum running out through the centre of the evolved ventricose portion. But perhaps the most instructive and convincing example of all was the following:—One of the large cnidæ of *Corynactis viridis* had shot about half of its wire with rapidity, when a kind of twist or kink occurred against the nipple of the cnida, whereby the process was suddenly arrested. The projectile force, however, continuing, caused the impediment to yield, and minute portions of the thread flew out piecemeal by fits and starts. By turning the stage screw I brought the extremity of the discharged portion into view, and saw it slowly evolving a little at a time. Turning back to the cnida, I saw the kink gradually give way, and the whole of the tangled wire quickly flew out through the nipple. I once more moved the stage, following up the ecthoræum, and presently found the true extremity and a large portion of the wire still inverted, slowly evolving, indeed, but very distinctly, throughout its whole course within the walls of the evolved portion. From all these observations there cannot remain a doubt of the successive eversion of the entire ecthoræum. It may be asked, What is the nature of the force by which the contained thread is expelled? That it is a potent force is obvious to any one who marks the sudden explosive violence with which the nipple-like end of the cnida gives way and the contents burst forth, as also the extreme rapidity with which, ordinarily, the whole length is evolved. A curious example of this force once excited my admiration: the ecthoræum from a cnida of *Corynactis viridis* was in course of rapid evolution, when the tip came full against the side of another cnida already emptied. The evolution was momentarily arrested, but the wall of the empty capsule was seen to bend inward, and suddenly to give way, the ecthoræum forcing itself in, and shooting round and round the interior of the cnida. The most careful observations have failed to reveal a lining membrane to the cnida. I have repeatedly discerned a double outline to the walls themselves, the optical expression of their diameter; but have never detected any, even the least, appearance of any tissue starting from the walls as the ecthoræum bursts out. My first supposition, reluctantly resigned, was that some such lining membrane of high contractile power lessened, on irritation, the volume of the cavity, and forced out the wire. The cnida is filled, however, with a fluid. This is very distinctly seen occupying the cavity, when, from any impediment, such as above described, the wire flies out fitfully—waves and similar motions passing from wall to wall; sometimes even before any portion of the wire has escaped, the whole mass of tangled coils is seen to move irregularly from side to side, within the capsule, from the operation of some intestine cause. The emission itself is a process of injection, for I have many times seen floating atoms driven forcibly along the interior of the ecthoræum, sometimes swiftly, and sometimes more deliberately. Nothing that I have seen would lead me to conclude that the wall of the cnida is ciliated. I consider, then, that this fluid, holding organic corpuscles in suspension, is endowed with a high degree of expansibility; that, in the state of repose, it is in a condition of compression by the inversion of the ecthoræum; and that on the excitement of a suitable stimulus it forcibly exerts its expansile power, distending, and consequently projecting the tubular ecthoræum, the only part of the wall that will yield without actual rupture. The cnidæ cannot, I think, be regarded in the light of cells, since they are but the contents of other vesicles, which thus present a higher claim to the character of cell-wall. In the craspeda of *Sagartia parasitica* may be seen many of the chambered cnidæ, bearing this outer envelope, which, without determining anything concerning its nature, I shall distinguish as the *peribola*. Many of the cnidæ have ruptured their investing membrane, which gives way at no special point, sometimes at the anterior end, sometimes at the posterior, and as frequently all down the side. The peribola thus ruptured, may be seen in many instances still hanging about the cnida, while others are quite free from any remains of it, and in some cases I have seen the cnida still enveloped in its peribola, unruptured. The peribola I have seen investing, and hanging around the cnida of the spiral and globate kinds, and this circumstance has afforded me an additional ground for presuming the latter to belong to this category of organs (*fig.* 4, D, *q*). It appears necessary that the cnida should set itself free by the rupture of its peribola before it can effect the emission of its ecthoræum. At least I have never met with an example to the contrary. The possession of stinging powers by the whole group of the *Cœlenterata* has long been known: powers which are capable of destroying the life of many soft-bodied organisms. These powers have been assigned to the cnidæ, and many facts may be adduced in support of the opinion. It is known experimentally that the ecthoræa are capable of penetrating soft membranes; thus, Gosse exposed a bit of tough cuticle to the action of the tentacles of *Tealia crassicornis*. On examining it, the ecthoræa were found to be buried in its substance, with the cnidæ standing up endwise. That a poisonous fluid is injected into the punctures thus made seems highly probable, considering the pain, and, in many cases, sudden death which follows upon the insertion of the barbed ecthoræa. Thus many persons have felt a stinging sensation on handling certain jelly fishes and sea anemones. Fishes have been known to die in great agony a few minutes after having been stung on the lip by various *Hydrozoa* and *Actinozoa*. Dr. Waller records the effects which followed upon his allowing the tentacles of *Actinia mesembryanthemum* to touch the tip of his tongue. "The result [of the experiment] was such as to satisfy the most sceptical respecting the offensive weapons with which it is furnished. The animal seized the organ most vigorously, and was detached from it with some difficulty after the lapse of about a minute. Immediately a pungent acrid pain commenced, which continued to increase for some minutes until it became extremely distressing. The point attacked felt inflamed and much swollen, although to the eye no change in the part could be detected. These symptoms continued unabated for about an hour, and a slight temporary relief was only obtained by immersing the tongue in cold or warm water. After this period the symptoms gradually abated, and about four hours later they had entirely disappeared. A day or two after, a very minute ulceration was perceived on the apex of the tongue, which disappeared after being touched with nitrate of silver." ('Proceedings of the Royal Society,' 1859.) Attempts made by Gosse to ascertain the alkalinity or acidity of the supposed poisonous fluid gave no decided results either way; but the tests employed were not sufficiently delicate to determine the question. "Admitting," says Gosse, "the existence of a venomous fluid, it is difficult to imagine where it is lodged and how it is injected. The first thought that occurs to one's mind is, that it is the organic fluid which we have seen to fill the interior of the cnidæ, and to be forced through the everting tubular ecthoræa. But if so, it cannot be ejected through the extremity of the ecthoræum, because if this were an open tube, I do not see how the contraction of the fluid in the cnida could force it to evolve; the fluid would escape through the still inverted tube. It is just possible that the barbs may be tubes open at the tips, and that the poison fluid may be ejected through these. But I rather incline to the hypothesis that the cavity of the ecthoræum in its primal inverted condition while it yet remains coiled up in the cnida, is occupied with the potent fluid in question, and that it is poured out gradually within the tissues of the victim, as the evolving tip of the wire penetrates farther and farther into the wound."

With this formidable array of offensive weapons the fixed, apparently helpless, soft-bodied polype is admirably adapted to grapple successfully with the more active mollusks, annelids, crustaceans, and minute organisms which form its ordinary food. The hard-cased shrimp or prawn may, with impunity, amuse itself with throwing its long flexible feelers or antennæ across the disk of the expanded sea anemone or coral, but should it attempt to come to closer quarters for the purpose of biting a morsel out of the body of the polype it may succeed in obtaining a few mouthfuls, but the chances are that the soft-bodied, dart-bearing polype will succeed in discharging some of the darts (ecthoræa) into the inner tissues left exposed by weak points in the hard mail of the crustacean. In such case the victory would ultimately be on the side of the polype, who would digest the crustacean, and thence obtain the nutrient matter requisite to repair the damages done to it by its stronger and more active enemy. The time required for the complete digestion of a good sized shrimp varies from two to six or eight hours; the process apparently consists of a combination of great pressure with the action of some solvent, for when discharged all the hard parts of the crustacean are in position, although much compressed, and slightly distorted from some of the joints having yielded; while the soft inner parts are almost entirely dissolved out. Pressure, however, is not essential to the digestive process, for if pieces of crustacean muscle be placed in a perforated silver globe the same result is produced. The solid portion of the food is usually retained in the digestive cavity, and it is there that the process of digestion is carried on; it is rarely that the solid parts pass into the somatic cavity, and then apparently from accidental or abnormal causes only, while there is no positive evidence to show that the lining membrane of the general cavity of the body is capable of digesting food. It is a frequent practice for aquaria keepers to feed these creatures with the muscles of vertebrate animals, such as beef, etc., but this fare is unsuited to them, for although at times they may reduce it to a more or less pulpy condition, yet frequently the meat is taken in, retained for hours, and again discharged without having undergone much alteration. This indicates that their digestive powers are not capable of obtaining the full amount of nutriment from this kind of food. Individuals fed on meat almost invariably grow smaller and ultimately pine away as though they had been starved. The fluid which occupies the general cavity of the body is clear and transparent, and is generally supposed to be simply sea-water; but it is really so modified as to play the same function in these animals as the blood does in those of more special organization. Observations on its character and properties are much wanted. It is more or less charged with albumen in solution, and abounds in minute disks or granules of a yellow colour, and having a diameter varying from ·0001 to ·0008 of an inch in diameter. It is doubtful if the *Zoantharia* have a liver or anything analogous to it; but in some genera the wall of the digestive cavity is lined with a yellowish or salmon red tissue, having a gland-like structure, which Gosse feels confident is the liver.

Geological Distribution of the Zoantharia.

In treating this branch of the subject the classification of Milne-Edwards and Haime as modified by Bronn will be adopted. The tables given by Bronn will also be used, with such alterations as we are able to give from more recent data. The general summary of the distribution of the species is contained in the table here given. The number of dots indicates the relative importance of the groups.

Thus . indicates orders.
. . „ sub-orders.
. . . „ families.
. . . . „ sub-families.

	Fossil Genera and Species.														Both fossil and living.		Living only.		Total of all known.	
	Full number of		Palæo-zoic.		Mesozoic.						Cainozoic.									
					Trias.		Oolitic.		Creta-ceous.		Eocene.		Neogene.							
	g.	sp.	g.	sp.	g.	sp.	g.	sp.	g.	sp.	g.	sp.	g.	sp.	g.	sp.	g.	sp.	g.	sp.
. Sclerodermata.																				
. . Rugosa.																				
. . . Cystiphyllidæ	1	8	1	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	8
. . . Cyathophyllidæ	35	208	35	208	—	—	—	—	—	—	—	—	—	—	—	—	—	—	35	208
. . . Cyathaxonidæ	1	6	1	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	6
. . . Stauriidæ	4	5	3	4	—	—	—	—	1	1	—	—	—	—	—	—	—	—	4	5
. . (Dubia)	4	5	4	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	5
. . Tabulata.																				
. . . Theciidæ	2	4	2	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	4
. . . Seriatoporidæ	3	3	3	3	—	—	—	—	—	—	—	—	—	—	—	—	1	6	4	9
. . . Favositidæ																				
. . . . Pocilloporina	1	6	1	6	—	—	—	—	—	—	—	—	—	—	—	—	1	11	2	17
. . . . Halysitina	5	29	5	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	29
. . . . Chætetina	6	30	6	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	30
. . . . Favositina	6	44	5	43	—	—	—	—	1	1	—	—	—	—	—	—	—	—	6	44
. . . . Milleporina	9	31	6	20	—	—	1	1	1	7	1	3	—	—	1	—	2	5	10	36
. . Tubulosa.																				
. . . Auloporidæ	2	7	2	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	7
. . Aporosa.																				
. . . Turbinoliidæ.																				
. . . . Caryophylliana	14	80	—	—	—	—	3	8	6	16	3	19	7	37	4	1	8	19	18	98
. . . . Turbinoliana	7	34	—	—	—	—	—	—	1	3	6	23	4	8	2	—	6	32	11	66
. . . Dasmidæ	1	1	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	1	1
. . . Oculinidæ.																				
. . . . Oculinacea	8	21	—	—	—	—	2	4	3	7	2	3	4	7	2	—	7	16	13	37
. . . . Stylasteracea	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	13	5	13
. . . Stylophoridæ	2	7	—	—	—	—	—	—	—	—	2	4	1	3	1	—	2	9	3	16
. . . Astræidæ.																				
. . . . Eusmiliana	35	263	—	—	1	1	14	78	24	161	10	24	6	9	5	—	11	50	41	313
. . . . Astræina	49	498	—	—	7	22	18	196	31	200	13	26	23	53	21	1	37	252	65	749
. . . Echinoporidæ	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	10	1	10
. . . Merulinidæ	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	7	1	7
. . . Fungidæ.																				
. . . . Lophoserina	9	42	1	4	—	—	3	8	3	21	3	7	2	2	1	—	9	10	17	52
. . . . Fungiana	3	5	—	—	—	—	—	—	3	5	—	—	—	—	—	—	7	16	10	21
. . Perforata.																				
. . . Madreporidæ	12	38	—	—	—	—	—	—	2	3	8	16	8	19	7	—	12	28	17	66
. . . Poritidæ.																				
. . . . Poritina	7	21	2	4	—	—	2	9	—	—	1	6	2	2	2	—	6	25	11	46
. . . . Alveoporina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	3	2	3
. Malacodermata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	41	226	41	226

Geographical distribution of the Zoantharia. The following table is taken from Bronn.

	Number of living genera and species.		Panama, Peru.		New Holland, Pacific Ocean.		China, Philippines, Sunda Island, East Indies.		East African islands, Red Sea.		Bermuda, Antilles, West Indies.		West Africa.		Middle Atlantic.		East America.		Cape of Good Hope.		Chili, Falkland Islands, Terra del Fuego.		Japan.		Canaries, Mediterranean.		North Sea.		North-west America, Greenland.		Unascertained.	
	g.	s.	g	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g	s.	g.	s.	g.	s.	g.	s.	g.	s.
. Sclerodermata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . Tabulata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Theciidæ	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Seriatoporidæ.	1	6	—	—	—	—	1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
. . . Favositidæ.	3	16	—	—	1	1	3	3	2	6	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	—	—	2	6
. . Aporosa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Turbinoliidæ.	14	51	—	—	1	2	4	18	—	—	1	1	—	—	—	—	—	—	—	—	2	3	2	3	5	9	3	5	—	—	7	10
. . . Dasmidæ	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Oculinidæ.	12	29	—	—	4	7	4	5	1	1	1	1	—	—	1	1	—	—	—	—	—	—	2	2	1	1	1	1	—	—	4	7
. . . Stylophoridæ.	2	9	—	—	1	1	2	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
. . . Astræidæ	48	302	—	—	21	75	34	66	15	45	19	31	1	1	—	—	1	1	—	—	—	—	—	—	1	3	—	—	1	1	33	86
. . . Echinoporidæ.	1	10	—	—	1	2	1	3	1	6	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Merulinidæ	1	7	—	—	1	6	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Fungidæ	16	26	—	—	7	7	8	10	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	9
. . Perforata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Madreporidæ.	12	28	—	—	3	8	7	10	2	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	5	1	1	—	—	2	3
. . . Poritidæ	8	28	—	—	4	6	2	5	3	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	5
. Malacodermata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
. . . Actinidæ	41	226	4	4	4	20	3	3	16	30	12	23	5	6	3	3	5	7	4	4	5	7	—	—	15	20	17	57	3	7	5	9

In Gosse's 'Actinologia Britannica' the number of species assigned to the British shores is 75, of which by far the greater number belongs to the families *Turbinolidæ* and *Actinidæ* as defined by Milne-Edwards and Haime. The definitions of the British genera, together with the number of British species, are thus stated by Gosse.

Actinoloba.—Blainville.—Base considerably broader than the column; its outline often undulate, but entire. Column pillar-like in the expanded state; the margin forming a thickened parapet or low wall; separated from the tentacular disk by a groove or fosse. Surface perfectly smooth, without suckers, but pierced with loopholes. Substance approaching to pulpy. Disk deeply frilled at the margin, thinly membranous. Tentacles short, slender, not arranged in distinguishable circles, scattered at their commencement about half breadth of the disk, becoming gradually smaller, more numerous, and densely crowded as they approach the border. Mouth surrounded with a thick lip; furnished with only a single gonidial groove, surrounded by a single pair of tubercles. Acontia emitted somewhat reluctantly, but copiously upon occasion.

A. dianthus is the only British species.

Sagartia.—Gosse.—Base broader than the column; its outline often undulate but entire. Column in the expanded state pillar-like, sometimes low and thick, sometimes tall and slender; the margin notched or tentaculate, without parapet or fosse. Surface studded with suckers, which do not form permanent warts; pierced with loopholes. Substance fleshy or pulpy. Disk sometimes wavy, more commonly plane, sometimes slightly turned over at the edge. Tentacles varying in number, form, and arrangement in the different species. Mouth generally elevated on a more or less conspicuous cone; furnished with two gonidial grooves, each with its pair of tubercles. Acontia emitted freely and copious. There are 15 British species, namely, *S. bellis*, *S. miniata*, *S. rosea*, *S. ornata*, *S. ichthystoma*, *S. venusta*, *S. nivea*, *S. sphyrodeta*, *S. pallida*, *S. troglodytes*, *S. viduata*, *S. parasitica*, *S. pura*, *S. coccinea*, *S. chrysosplenium*.

Adamsia.—Forbes.—Base adhering to the inner lips of univalve shells; greatly expanded laterally in two wing-like lobes, which gradually advancing on each side, at length surround the mouth of the shell, and meet on the outer side of the body whorl. Column greatly depressed; margin forming a low, sharp parapet, with a distinct fosse. Surface smooth towards the summit, striated or irregularly furrowed on the outer (= lower part); pierced with loopholes, which, on the outer (= lower) part form permanent warts. Substance fleshy. Disk long oval, almost linear, smooth. Tentacles numerous, sub-marginal, short, crowded, imperfectly retractile. Mouth protrusile, large, thrown into loose folds, but not furrowed. Acontia emitted freely and copiously. *A. palliata* is the only British species.

Phellia.—Gosse.—Base adhering to rocks; little exceeding the column. Column pillar-like in expansion; the margin tentaculate without parapet or fosse. Surface smooth, pierced with loop-holes; partly clothed with a tough epidermis, which is rough externally, firmly adherent to the skin. Disk concave; the edge not undulate. Tentacles few, in more than one row, barred. Mouth not raised on a cone; lip thickened. Acontia discharged, but reluctantly. There are four British species, namely, *P. murocincta*, *P. gausapata*, *P. picta*, *P. Brodricii*.

Gregoria.—Gosse.—Base not broader than the column. Column a low pillar, strongly invected, very inflatable in irregular lobes; the margin forming an irregularly undulate parapet, separated from the tentacles by a deep but narrow fosse which is never obliterated. Surface smooth, but becoming transversely wrinkled in contraction; without suckers; perforated with few, but very conspicuous loop-holes; these are arranged in longitudinal lines, on the swellings which correspond to the intersepts. Substance pulpy. Disk plane; not exceeding the column; smooth, without conspicuous radii. Tentacles moderately short, blunt, unicolorous; not perfectly retractile. Mouth set on a cone; lip thin; two gonidial grooves, each with a pair of small tubercles. Acontia emitted sparsely. *G. fenestrata* is the only British species.

Aiptasia.—Gosse.—Base adhering to rocks, readily detached; often not equalling the medium diameter of the column. Column trumpet-shaped, many times higher than wide, very changeable in shape from irregular distension, margin tentaculate; surface minutely corrugated, adhesive, but without distinct suckers; pierced with loop-holes. Substance pulpy. Disk greatly expanded, membranous, concave. Tentacles in several rows, long, lax, irregularly flexuous, perforate at the top, the first row longest, scarcely retractile. Mouth not set on a cone; lip thin; stomach protrusile. Acontia abundant, but not often spontaneously extruded. One British species, *A. Couchii*.

Anthea.—Johnston.—Base slightly adherent; broader than the column; its outline irregularly undulate. Column forming a low thick pillar; the summit expanding; the margin notched, and bearing budding tentacles, with no distinct parapet or fosse. Surface cancellated by the intersection of longitudinal furrows and transverse wrinkles. No suckers, warts, nor loop-holes. Substance warty. Disk membranous, very expansile, undulate at the margin. Tentacles numerous, in several rows, sub-marginal, very long, lax, irregularly flexuous; scarcely retractile. Mouth elevated on a low cylindrical wart. Acontia wanting. There is only one species, and that is found on the shores of England, as well as on the western and southern coasts of Europe generally, *A. cereus*.

Actinia.—Linnæus.—Base adhering to rocks; considerably exceeding diameter of column. Column pillar-shaped, usually much wider than high: margin greatly developed, smooth, separated by a broad, but shallow fosse from the outer tentacles; a circle of vividly coloured spherules projecting from the inner surface of the wall of the fosse: surface delicately smooth, imperforate, non-adhesive; substance fleshy. Disk greatly expanded and overarching; concave. Tentacles in several rows; moderately long, nearly equal; unicolorous; wholly retractile. Mouth set on a protrusile cone; two pairs of gonidial tubercles, brightly coloured. One British species. *A. mesembryanthemum.*

Bolocera.—Gosse.—Base adherent; not much exceeding the column. Column pillar-like, the diameter and height sub-equal. Surface generally very smooth, studded with small warts, remotely scattered. Substance fibro-cartilaginous. Disk smooth, circular in outline, not overlapping the column. Tentacles short, thick, constricted at the foot, obtusely pointed, longitudinally furrowed; flexuous and mobile; easily separated; not retractile. Mouth not raised on a cone; stomach capable of being greatly protruded. *B. Tuediæ* and *B. eques* are British species.

Bunodes.—Gosse.—Base exceeding the column; its outline generally undulate. Column pillar-like; the height in extension, considerably exceeding the diameter. Surface studded with permanent rounded warts set in vertical lines, which are separated by bands of plain skin. Margin denticulate. Substance firmly fleshy. Disk flat, circular in outline; scarcely overlapping the column. Radii conspicuously marked. Tentacles not very numerous, arranged in several rows, sub-marginal; moderately long and slender, obtusely pointed, smooth, not very flexuous; marked (in the more typical species) with irregular white spots on the face; perfectly retractile. Mouth not raised on a cone; stomach not habitually protruded; gonidial tubercles generally conspicuous. There are four British species, namely *B. gemmacea, B. thallia, B. ballia, B. coronata.*

Tealia.—Gosse.—Base exceeding the column. Column not pillar-like, the diameter usually much exceeding the height. Surface studded with permanent rounded warts, which are hollow, and have strong adhesive power, irregularly scattered or not set in vertical lines. Margin denticulate. Substance cartilaginous. Disk flat, circular in outline, considerably overlapping the column. Radii inconspicuous. Tentacles not very numerous, arranged in several rows, submarginal; short, thick, and conical; unicolorous, or marked with undefined rings or bands of alternate colours; perfectly retractile. Mouth raised on a cone; stomach habitually protruded to a great extent. Muscular system highly developed; very dense, and of a cartilaginous firmness. Two British species are known, viz., *T. digitata* and *T. crassicornis.* There may be a third, which Mr. Cocks names *T. tuberculata.*

Hormathia.—Gosse.—Base coherent, greatly expanded. Column pillar-like, much corrugated, surrounded by a single horizontal row of warts. Disk slightly concave, scarcely exceeding the column. Tentacles moderately long and slender; perfectly retractile. *H. Margaritæ*, a native of Britain, is the only known species.

Stomphia.—Gosse.—Base adherent, expanded. Column pillar-like; without warts or suckers, imperforate (?); skin much corrugated; substance not at all cartilaginous, but soft and lax. Disk very protrusile. Tentacles perfectly retractile. Acontia not present. The only known species, *S. Churchiæ,* is found on the coasts of Scotland.

Ilyanthus.—Forbes.—Column pear-shaped, tapering to a blunt point at the inferior extremity, which is probably perforated. Surface smooth, without suckers, warts, or loopholes. Tentacles of one kind only, marginal, numerous (*i. e.*, exceeding thirty). Mouth of the ordinary form, with no prominent gonidial development. Two British species; *I. Scoticus,* and *I. Mitchellii.*

Peachia.—Gosse.—Column cylindrical, pear-shaped, or swelling in the middle, rounded at the posterior extremity, where there is an orifice; margin entire, forming an indistinct parapet. Surface smooth, without loopholes, but studded in every part with very minute and very numerous suckers. Disk flat, or very slightly conical, smooth. Tentacles of one kind, twelve, thick, short, obtusely pointed; marginal; imperfectly retractile. Mouth not elevated on a cone; lip thin, abrupt, protrusile, sometimes lobed. A single gonidial groove, the edges of which are soldered together, so as to form a tube, which terminates above in a thickened, expanded rim (*conchula*), the margin of which is more or less divided. Acontia wanting. There are three British species, viz., *P. hastata, P. triphylla,* and *P. undata.*

Halcampa.—Gosse.—Column long, slender, cylindrical, or swollen at the inferior extremity, which appears to be imperforate; no distinct margin. Surface without loopholes, but studded with minute suckers. Disk flat. Radii distinct. Tentacles of one kind, few (less than twenty), marginal or submarginal, cylindrical, obtuse, perfectly retractile. Mouth simple, no obvious gonidial development. There are two British species, *H. chrysanthellum,* and *H. microps.*

Edwardsia.—Quatrefages.—Column long, slender, cylindrical, divided into three distinct regions, of which the two terminal are retractile within the central one. Anterior region forming a short thick pillar (*capitulum*) of less diameter than the central, and more delicate. Central region (*scapus*) covered by a skin (*epidermis*) more or less thick and opaque. Posterior region (*physa*) thin, pellucid; inflatable like a bladder; imperforate (?). Disk sometimes flat, sometimes conical. Tentacles of one kind, few (less than thirty), marginal, arranged in one or two rows; slender, moderately long, pointed; perfectly retractile. Mouth simple, no obvious gonidial development. *E. callimorpha, E. Allmanni, E. Goodsiri,* and *E. carnea* are British; and *E. Beautempsii* may be.

Arachnactis.—Sars.—Column moderately long, cylindrical, rounded at the inferior extremity, but not swollen, imperforate. Surface capable of temporary adhesion, and therefore probably studded with minute suckers. Tentacles of two kinds, the one marginal, very long, slender; the other gular, short, few in each series, not retractile. Mouth a simple slit. Habit, freely swimming in the sea. *A. albida* is the only British species recorded by Gosse.

Cerianthus.—Dellechiaje.—Column lengthened, cylindrical, swollen and bulb-like at the inferior extremity, which is perforated with a distinct orifice; expanding trumpet-like at the margin, which merges into the tentacles, without parapet or fosse. Surface smooth, without loopholes, or (apparent suckers) usually enveloped in a loose non-adherent tube closed at the lower end, of tough, membranous texture, and ragged exterior. Disk wider than column, but not overarching, funnel-shaped, with conspicuous radii. Tentacles of two kinds; the one marginal, the other gular; both in perfect circles, those of each equal *inter se,* moderately numerous, slender; absolutely incapable of retraction. *C. Lloydii* is the only British species. It is probable that the species described as *Actinia vermicularis* by Forbes, and dredged by him from the Shetland seas, may belong to this genus.

Capnea.—Forbes.—Base expanded, swollen, adherent. Column cylindrical, pillar-like; the margin forming a thick parapet with a fosse. Surface smooth, without loopholes, invested with a woolly epidermis. Disk circular, entire. Tentacles very short, truncate, retractile. *C. sanguinea* from the seas off the Isle of Man and Falmouth is the only species.

Aureliana. — Gosse. — Base expanded, adherent. Column conico-cylindrical, low, the margin forming a thick parapet with a fosse. Surface smooth, without suckers or loopholes; invested with a deciduous epidermis. Substance firm and coriaceous, opaque. Disk flat, entire; radii distinct. Tentacles in several rows, very short, knobbed; the heads more or less bilobate, and differing in form in the different rows; perfectly retractile. Mouth, slit-like, furrowed. Stomach-wall protrusile. There are two British species. *A. augusta,* and *A. heterocera.*

Corynactis.—Allman.—Base expanded, adherent. Column versatile, tall; the margin forming a parapet with no fosse. Surface smooth, without suckers or loopholes; not invested with any separable epidermis. Substance fleshy or pulpy, pellucid. Disk flat, entire, circular. Tentacles in several rows, all of the same form, each consisting of a conical stem and a globular head; perfectly retractile. Mouth simple, protrusile; lip coarsely furrowed; stomach evertile. There is but one British species, *C. viridis.*

Zoanthus.—Cuvier.—Base permanently attached; spreading over rocks, stones, or shells, in either a linear or incrusting manner. Column pillar-like, higher than wide; margin cut into strongly-marked teeth, which are united by a thin membrane. Surface smooth, excreting a mucus, in which occasionally grains of sand become imbedded, constituting an adventitious epidermis. Disk slightly concave; radii inconspicuous. Tentacles conical, pointed, similar in structure to those of the *Actinidæ;* wholly retractile. Mouth more or less protrusile, simple. Three British species have been discovered; *Z. Couchii, Z. sulcatus,* and *Z. Alderi.*

Caryophyllia.—Lamarck.—Corallum simple, generally obscure, often with an expanded base, permanently adherent; outline ovate or circular. Columella composed of several thin, narrow, pointed vertical plates. Palules broad, entire, in a single circle. Septa straight, broad, projecting and forming six systems. Ribs (*costæ*) straight; developed only towards the summit, granulated. Soft parts translucent, the column very extensile, the disk protrusile, the tentacles set in several rows, diminishing in size from the outer row inwards, each consisting of a stem with a globular head. There is but one British species, *C. Smithii.*

Paracyathus.—Milne-Edwards and Haime.—Corallum simple, subturbinate or cylindrical with an expanded base, permanently adherent. Columella very broad, terminated by a papillous surface, and formed by processes that appear to arise from the lower part of the inner edge of the septa. Palules of divers orders, forming two or more circles; in general lobed at the summit, narrow, tall, and appearing also to arise from the lower part of the inner edge of the septa; their size diminishing as they approach the columella. Plates (*septa*) nearly equal, very slightly salient and closely set; their lateral surfaces strongly granulated and sometimes presenting traces of imperfect dissepiments. They form four or five cycles, and the systems are equally developed. Ribs (*costæ*) nearly equal, straight, closely set, projecting very little, and delicately granulated. Three British species are known; *P. Tascilianus, P. Thulensis, P. pteropus.*

Sphenotrochus.—Milne-Edwards and Haime.—Corallum simple, free, with no trace of adherence, wedge shaped, the superior extremity wider in all directions than the inferior; transversely elliptical. Columella a single lamina, occupying the greater axis of the calyx; its upper margin flexuous and bilobate. Palules entirely wanting. Plates (*septa*) extending to the columella, or meeting in the centre of the visceral chamber; broad, slightly salient, forming three cycles and six systems. Ribs (*costæ*) broad, not very prominent, in general, crisped or represented by a series of papillous tubercles. There are two British species, viz., *S. Macandrewanus*, and *S. Wrightii.*

Ulocyathus.—Sars.—Corallum simple, free, turbinate, with traces of adherence (in the young state), on a very short, wedge-shaped, crooked, pointed base. Columella and palules entirely wanting. Ribs (*costæ*) not at all prominent, sometimes obscure. Plates (*septa*) very thin, high, very salient above the margin of the cups, distinct throughout their length. Calyx very deep; the margin sinuous and crisped. One British species, *U. arcticus.*

Lophohelia.—Milne-Edwards and Haime.—Corallum tree-like or forming a branching thicket, the branches coalescing; this form results from a gemmation irregularly alternate and subterminal. There is no true cœnenchyma, but the walls are very thick and scarcely-ribbed. Calices having a deep cavity with a reverted lamellar edge. Columella and palules wanting. Plates (*septa*) entire, salient, unequal, the principal ones united towards the lower part of their inner edges at the bottom of the visceral cavity. *L. prolifera* is the only British species.

Hoplangia.—Gosse.—Corallum incrusting foreign bodies. Corallites rather short, formed by buds which spring from an expansion around the base of the parent permanently united to it (but not to each other) by the inferior portions of their walls. Wall surrounded by a thin porcellanous coat (*epitheca*), which permits the ribs to be traced through it; granulate. Ribs (*costæ*) thin, sharp, low, very unequally distinct. Columella a broad surface of rough papillæ, merging into the plates. Palules wanting. Plates (*septa*) thin, scarcely salient, unequal, straight, granulose, toothed on the edges, except the upper edges of the primaries, which are nearly entire. *H. Durotrix* is the only species; it has been found in Weymouth Bay.

Balanophyllia.—Wood.—Corallum simple, adherent, sub-pedicellate, cylindrical or subconical. Columella well developed, but not projecting at the bottom of the calyx; of a sponge-like appearance. Plates (*septa*) thin, close-set; those of the last cycle well developed. Ribs (*costæ*) distinct, narrow, nearly equal, crowded. Soft parts, actinia-like, richly coloured, with a protrusile mouth, not conspicuously furrowed, and bluntly pointed, warted tentacles without terminal knobs. *B. regia* is the only British species.

In 1865 a new British genus and species were described by Gosse ('Annals of Natural History'); and we give his account of it here.

Ægeon.—Gosse.—Base adherent to walls with a moderate tenacity; broader than the medium diameter of the column. Column irregularly distensible, not sinuous, somewhat versatile, but generally forming a tall, erect, thick pillar, the summit expanding; the margin tentaculate; surface longitudinally fluted, each flute studded with a single row of minute warts; no suckers or loopholes. Substance pulpy, membranous. Disk expanded, membranous, concave, revolute. Tentacles numerous, in several rows, long, lax, irregularly flexuous, scarcely retractile. Mouth not ordinarily set on a cone, but pouted after the reception of food; lip thin. Gonidial tubercles prominent. Acontia wanting. *Ægeon Alfordi* is the name of the species.

The data connected with the general geographical distribution of these organisms are scattered so widely through zoological literature that the task is beyond the powers of the compiler of this article; and therefore the detailed tables given by Bronn will form the basis of a few general observations, although such tables are now several years old, and much has been learnt since they were drawn up. The numbers must not, therefore, be considered as representing the present state of our knowledge. The *Rugosa* are unrepresented in modern seas. The *Tabulata* are represented by 4 genera and 22 species; the genera are *Seriatopora, Pocillopora, Millepora,* and *Heliopora.* All the species of *Seriatopora* are recent; and so far as we know all of them inhabit the Red Sea. The 11 species of *Pocillopora* are more widely scattered; 5 of them occur in the seas washing the southern shores of Asia, and 4 of them are found in the Red Sea; 2 species are reported from the Mediterranean, while the localities of 5 are unknown. *Millepora* is the only one of the four genera which has representatives in ancient and modern seas; there are 5 recent species; the Indian Ocean is the habitat of one species, the Red Sea of two, the Caribbean Sea of one, and there is one species whose native country is unknown. The only species of *Heliopora* is a native of the Indian Ocean. Almost all the species of the *Tabulata* occur in low northern latitudes, and the majority of them are met with in the seas of the southern confines of Asia, and in the Mediterranean; while few have as yet been reported from the western hemisphere. It is especially noticeable how little connection there appears to be between the extinct and living forms. Thus 125 species are known from the palæozoic formations, none from the triassic series; but one from the oolitic series; 8 from the cretaceous formation; 3 from the eocene; none from the later tertiaries; while, as already stated, there are 22 living species. While *Seriatopora* is only known by living forms, the genera most nearly allied to it, according to Bronn's arrangement, viz., *Rhabdopora, Dendropora,* and *Trachypora,* are only represented in palæozoic rocks. Again *Pocillopora* is recent, while *Cœnites,* closely allied to it, is exclusively palæozoic. These facts seem to indicate either that the evidence is yet very incomplete, or that the generally received classification is faulty. The order *Tubulosa* is confined to palæozoic rocks. The order *Aporosa,* so rich in species, is best represented in the Indian Ocean, the Red Sea, and the Mediterranean, a few species being scattered through the Pacific and Atlantic Oceans. By far the greater number are restricted to low latitudes and warm seas, a few stragglers only extending into the colder regions of the North Sea. The extinct forms are most concentrated in the mesozoic limestones. The living species of *Perforata* are more abundant than the extinct. They are for the most part dwellers in the Indian Ocean, the Red Sea, and Mediterranean, in the Eastern Hemisphere; and in the Caribbean Sea in the Western. The fossil species are most abundantly represented in the uppermost secondary and in the tertiary rocks. The *Malacodermata* are unknown in the fossil state, but this is probably due rather to their forms being less adapted for preservation than to their not having lived during the past epochs of the geological record. The living species are distributed all over the world, and there is probably no extensive coast line which does not support some species. The evidence as to their distribution is still very imperfect: so that at present we are scarcely in a position to draw conclusions with safety. The apparent richness or paucity of the malacodermatous faunas of various countries depends chiefly upon the amount of attention which has been given to them. The richest countries are those which have been most examined; as, for instance, the Red Sea, the Mediterranean, the West Indies, and the seas surrounding the shores of Britain. These remarks apply with greater or less force to all the other orders; so that great caution and much sifting of evidence is required before high importance can be attached to any general conclusions that may be drawn.

Those who require details respecting the extinct species should consult the general work by Fromentel; the papers by the same author in 'Paléontologie Française' and 'Caen Memoirs,' for the French species; those by Reuss in the 'Sitzungsberichte' of the Academy of Sciences at Vienna, for the German species; those by Ludwig in 'Palæontographica,' edited by Dunker and Meyer, for the Russian species; those by Sismonda, Felippi, and Seguenza, in the 'Memoirs of the Royal Academy of Science at Turin,' for the Italian species; and those by Dr.

Duncan in the 'Annals of Natural History,' 'Quarterly Journal of the Geological Society,' and 'Philosophical Transactions,' for the extinct forms of Australia, India, and the West Indies. The last-mentioned writer has also written an account of many British species in his 'Monograph of the British Fossil Corals, 2nd Series,' which is a continuation of the well-known work of Milne-Edwards and Haime.

Messrs. Duchassaing and Michelotti have given considerable attention to the West Indian species of this class; and in their latest memoir on them they announce some general conclusions to which they have been led respecting their geographical distribution. The *Malacodermata* are represented by the genera *Zoanthus*, *Palythoa*, and *Mammallifera*, which appear to be specifically more abundant in the Caribbean Sea than anywhere else. Amongst the *Aporosa* there are a few species belonging to the *Caryophyllidæ* and *Turbinolidæ*. The *Astræidæ* have a great development. The *Oculinidæ* are represented by several species. The *Fungidæ* are represented by a few *Lophoserinæ*. The *Perforata* afford a few genera only, namely, *Dendrophyllia*, *Madrepora*, and *Porites*. The *Tabulata* are represented by *Millepora*, which genus is rich in species in this area. The authors describe as many as 26 species. On comparing the statements here made on the authority of the Messrs. Duchassaing and Michelotti with those based on Bronn's tables, much discrepancy may be noticed; but it must be remembered that the researches on the Caribbean fauna were not published when Bronn's work was issued. Bronn only knew of one Caribbean species of *Millepora*; but a more careful examination of the district has increased the number to 26. In the Antilles some species of *Actinidæ* continuously cover large areas of ground; the species generally belonging to *Palythoa* or *Mammallifera*. Some of the Madrepores reach a large size, as for instance, *Madrepora*, *Meandrina*, *Heliastræa*, *Colpophyllia*, *Diploria*, *Dendrogyra*, and *Pectinia*, which frequently form masses of about two or three cubic feet. The species are abundantly developed individually, the bottom of the sea being as completely covered by them as it is by Algæ in Europe. The various species generally frequent certain parts of the shore only, so that a prolonged examination reveals the same evidence of arrangement in zones as is to be detected in the *Zoantharia* of the European shores. Some species are quite littoral, and are exposed to the air for several hours every day; they are confined to the *Actinidæ*, such as *Zoanthus*, *Palythoa*, and *Mammallifera*. In the rock pools containing a small quantity of water are found affixed to the sides and under the ledges of the rocks numerous species of *Neoporites*, *Cosmoporites*, and *Porites*. At the level of the lowest tide mark, and for a few yards horizontally on either side of it, occur species of *Astrea*, *Madrepora*, *Solenastrea*, *Phyllangia*, &c. At a greater depth, or in the zone permanently covered by from 5 to 10 feet of water, *Plexaura*, *Eunice*, *Mussa*, *Colpophyllia*, *Lithophyllia*, *Symphyllia*, and *Millepora* are the principal denizens. At still greater depths, or between 10 and 20 feet, *Dichocœnia*, *Stephanophyllia*, and *Desmophyllia* are met with. Beyond this depth the *Zoantharia* are comparatively less abundant.

Classification of the Zoantharia. The most generally accepted classification is that proposed by Milne-Edwards and Haime, of which an outline is given in POLYPIFERA, E. C. A modification of it is given by Bronn in his 'Klassen und Ordnungen der Thierreichs.' Other classifications have been since proposed by Ludwig in 'Palæontographica,' vol. xiv.; by Duchassaing and Michelotti in their 'Memoir sur les Corallaires des Antilles;' and by Verrill in the 'Proceedings of the Essex Institute,' iv. Although we feel how desirable it would be to give outlines of each of them, we find that were we to do so this article would be made too

ACTINOZOA.								
1st Class.	Actinia hexamera (Polypi).							
Sub-classes.	1. Hexactinia flabellata.							2. Hexactinia pinnata.
Orders.	1. Polycyathina; developing by eggs and buds.						2. Monocyathina, developing only by ova.	
Sub-orders.	Symphya: calices with or without exotheca; amalgamated together.				Encalypta; calices free, but connected by cœnenchyme.			
Families.	Phlæoda. Theca without common basis.	Chartoplintha. Theca with common basis.	Anablasta. Buds developed in the upper part.	Dendrophora. Dendritically ramified.	Placoda. Massed in flat masses.	Thromboda. Massed in knobs.		
Genus.	Species.	Species.	Species.	Species.	Species.	Species.	Species.	Species.
1. Liocyathina, with smooth calices and mesenteries; with and without tabulæ.	Stromatopora. Calamopora. Cumulipora. Chætetes. Eunomia, &c.	Römeria. Pleurodictyum, in part.	Favosites.	Aulopora.		Millepora.	Liocyathus. Pyrgia.	
2. Ptychocyathina. Calyx longitudinally divided; with and without tabulæ and columella.	Catenipora. Heliolites, &c.	Michelinia. Pleurodictyum, in part.	Cricopora. Seriatopora.	Syringophyllum. Trachipora.		Pocillopora. Porites. Dendracis.	Ptychocyathus. Cystiphyllum.	Ptychochonium.
3. Tæniocyathina. Calyx with tubercles or rudimentary septa; with and without tabulæ, columella, and synapticulæ.	Columnaria. Acervularia. Polytremacia, &c.	Agaricia, &c.	Madrepora.	Lithostrotion. Merycyathophyllia.	Lyellia. Smithia. Syringophyllum. Heterocœnia, &c.	Thamnastræa. Dimorphastræa. Asterocœnia. Columnastræa, &c.	Tæniocyathus. Heliophyllum. Merycyathophyllia. Dasmia.	Amplexus. Menophyllum. Acanthochonium. Cyathothäläæ.
4. Astrocyathina. Calyx with broad septa, reaching to the centre; with and without tabulæ, columella, and synapticulæ.	Lonsdaleia. Streptastræa. Meandastræa. Heliastræa. Pachimeris, &c.	Stauria, &c.	Merulina. Aphastræa, &c.	Eusmilia. Dendrophyllia, &c.	Pachyphyllum. Rhizangia. Lophosmilia. Galaxea, &c.	Dendrosmilia. Madracis. Echinopora, &c.	Astrocyathus. Aulophyllum. Cyclolites. Fungidæa. Turbinolia. Thecosmilia. Caryophyllia. Discocyathus. Microbacia. Dasmia, &c.	Amarygmophyllum. Anisophyllum. Hallia. Lophophyllum. Tetraphyllum. Hadraphyllum. Trochophyllum. Cyathodactylia. Diarygmaphyllum. Aulacophyllum. Zaphrentis. Cyathaxonia. Hexarygmaphyllum.

lengthy. All we can attempt then is to refer as briefly as possible to what appear to us to be the general features of each. The principal modifications suggested by Bronn are the exclusion of the *Antipathidæ* from the *Zoantharia;* the subdivision of the *Zoantharia,* for which he uses the nearly equivalent term *Polycyclia,* into the *Enallonemata* and *Paronemata,* the latter being formed for the reception of the single family, *Cerianthidæ,* on account of its having a double set of tentacles, each chamber being provided with two. There are other differences, but they mostly refer to nomenclature and the grouping of the genera. Ludwig bases his arrangement on the mode of development. He finds from the careful examination of the sections of palæozoic forms, that all which came under his notice were constructed upon the hexameral type. This, if true, breaks down what has long been considered to be the great distinction between palæozoic and neozoic corals. Externally the palæozoic forms appear to be quadripartite, but this is caused by a peculiar arrangement of the primary septa. Since, then, the *Rugosa* are hexameral like the other suborders, Ludwig abolishes it, and distributes the genera amongst them. His classification, as will be seen from the preceding table, has a very artificial appearance, since the groups have names descriptive of their external form: and all the genera are named upon the same plan, although this is not fully shown in the table. For example, in the first horizontal column with generic names, all the forms have smooth cells, and all have names beginning with *Lio:* and in like manner all those in the other horizontal rows have the prefix *Ptycho; Tænio,* or *Astro,* according to their position; the same method of naming is followed out in the vertical rows. Thus the well-known *Aulopora* appears in Ludwig's nomenclature in *Liodendrophora; Millepora* becomes *Liothromboda; Madrepora* becomes *Tænioanablasta;* and so we might proceed until the ordinary student would fail to detect his old friends under their new faces.

The classification of Duchassaing and Michelotti does not differ greatly from that of Milne-Edwards and Haime: but they insist upon the importance of certain characters which had been previously but little employed in classification, such as the duplication of the mesenteric laminæ, and the presence of acontia; and they call in question the practical applicability of Milne-Edwards' laws of the development of the septa to the tentacles. Thus in *Porites* there are twelve tentacles, but they are situated in one line, so that no mere inspection would induce one to conclude they were in two series. They even take exception to his law of development of the hard parts as a distinctive character. In Milne-Edwards and Haime's scheme, the number of cycles of septa is one of the most important characters; but Duchassaing and Michelotti say they could not decide in many cases whether a species had five or six cycles. They further state that it is not always true that the most prominent septa were first formed, and cite as illustrative cases, *Diploria crebriformis, Caryophyllia cyathus,* and others.

We may mention here that from the researches of Duthiers it appears that the *Antipathidæ,* which are usually placed amongst the *Alcyonaria,* should probably be ranked amongst the *Zoantharia.* Also, that *Calceola,* which has long been associated with the *Brachiopoda,* should be transferred to the Coral group.

The main features of Verrill's classification will be seen in the following brief summary :—

Class CNIDARIA, or POLYPI.

Order I. *Madreporaria.*

Sub-order I. *Stauracea* (*Madreporaria rugosa*).
  Families : *Stauridæ; Cyathophyllidæ; Cyathaxonidæ; Cystiphyllidæ.*
Sub-order II. *Fungacea.*
  Families : *Cyclolitidæ; Lophoseridæ; Fungidæ; Merulinidæ.*
Sub-order III. *Astreacea.*
  Families : *Lithophyllidæ; Mæandrinidæ; Eusmiliadæ; Caryophyllidæ; Stylinidæ; Astreinæ; Oculinidæ; Stylophoridæ.*
Sub-order IV. *Madreporacea* (*Madreporaria perforata*).
  Families: *Eupsammidæ; Gemmiporidæ; Poritidæ; Madreporidæ.*

Order II. *Actinaria.*

Sub-order I. *Zoanthacea.*
  Families : *Zoanthidæ; Bergidæ.*
Sub-order II. *Antipathacea.*
  Families : *Antipathidæ; Gerardidæ.*
Sub-order III. *Actinacea.*
  Families : *Actinidæ; Thalassianthidæ; Minyidæ; Ilyanthidæ; Cerianthidæ.*

There is a third order, the *Alcyonaria,* the families in which are given under ALCYONARIA, E. C. S.

ADANSONIA [E. C. i. col. 70]. This remarkable genus of plants has for a long period been represented by one species only, viz., the *A. digitata* of Africa, which rivals the mammoth tree of North America in its enormous girth, and the Victoria lily of South America in the great expanse of its delicate white blossoms. Of late years it has been increased by the discovery of a second species (*A. Gregorii*) in Australia. The Australian species closely resembles its African relative, but has a smaller fruit suspended on a short stalk. It also yields an agreeable acid drink, which is much relished by the inhabitants of the sultry climates where it flourishes, who call the tree, from this circumstance, the Sour Gourd, and Cream of Tartar tree. It was discovered by Gregory in his travels through North-West Australia; who describes the largest he saw as 85 feet in girth at two feet from the ground. More recent travellers in the same region repeatedly refer to isolated individuals and clumps of this tree, especially on and near the banks of the river Glenelg.

The range of the African baobab is more extensive than is apparently implied in the former article. Not only is it found in Senegal and Abyssinia, but it is met with on the west coast, near Angola and far away in the south, on the shores of Lake Ngama, near the 21st degree of S. latitude. In this neighbourhood, and generally in the south of Africa, it is called *Mowana,* while in the north it is called *Kaka,* or Monkey-bread tree. It is also called *Mbuyu,* or Calabash. Burton refers to it as the most characteristic feature in the flora of Eastern Africa, and as presenting a great variety of appearance. "In every region," says this traveller, "it shows some difference and peculiarity of formation. It is not found in the mountains of Usagara, rarely in Unyamwezi, or to the northward. In the northern regions of Usukuma it is common. There appears to be two varieties of this tree, similar in bole, but different in foliage and in general appearance. The normal species has a long leaf, and the drooping of the outer branches gives to the outline the form of a dome. The rarer variety, observed only in Usagara, has a small leaf, in colour like wild indigo; and its arms striking upwards, assume the form of a bowl." It is said to be more bulbous a short distance from the sea than on the coast, where the trunk is columnar, and the heavy extremities weighed down by the periodical winds, give it the shape of a lumpy umbrella. *A. digitata* is a conspicuous feature in the scenery on the Zambesi river. Baines has painted a specimen growing at Nyamak, a village on the banks of the Zambesi, which had a girth of about 50 feet, and which was in blossom at the time the sketch was made, viz., Nov. 14, 1859.

(Lindley and Moore, *Treasury of Botany,* 1866; Burton, *Journ. Roy. Geog. Soc.,* xxix., p. 63, 1859.)

ÆDELFORSITE [E. C. i. col. 72], the name for two species of mineral; the one a silicate of lime, and the other a hydrosilicate of alumina and lime. The silicate of lime occurs massive, fibrous, or feathery, and has a white or greyish colour combined with a vitreous lustre and a low degree of transparency. Its specific gravity is 2·58 and degree of hardness 5·5. It is probably an impure wollastonite, as has been suggested by Forchhammer. It is found in the following localities: Cziklowa, in the Bannat; Ædelforss, in Sweden; and Gjelleback, in Norway.

The second mineral referred to is a red zeolite or hydrous silicate of alumina and lime. This form is usually called Retzite. It occurs in fibrous aggregations of a white, light grey, or reddish colour, and vitreous lustre. The specific gravity is 2·6, and hardness 6. It has the usual properties of the zeolites, such as intumescing under the blow-pipe, and gelatinising with acids. In this respect it agrees with Heulandite [HEULANDITE, E. C.], but it differs somewhat from that mineral in its composition. The following is an analysis of Retzite by Retzius :—

Silica	60 28
Alumina	15 42
Peroxide of iron	4·16
Lime	8·18
Magnesia and Peroxide of Manganese	0·42
Water	11·07
	99·53

ÆPYORNIS, or EPIORNIS (St. Hilaire). Under DINORNIS [E. C. vol. ii. col. 346], a slight notice is given of the only species then known. Although only a few eggs and bones have been found since the date of St.-Hilaire's paper, some extra remarks seem to be required, partly on account of *Æpyornis maximus* being the largest bird of which any evidence exists, and partly because the eggs and bones discovered in 1851 may not have been the earliest facts recorded respecting this species. Travellers in the East, and eastern traditions, have frequent allusions to a gigantic bird of prey. The most moderate of the statements assign to the bird a size so colossal that naturalists have at once condemned the statements as mere fables, and the creations of the lively imagination of the eastern mind. Sindbad the Sailor describes his experiences in connection with the *rukh* on two distinct voyages. He says the egg was like a large dome, and that it was 55 paces in circumference. The bird itself was able to carry off elephants with the greatest ease. The Arabian and Persian literatures contain several notices of a bird which carried off elephants as the hawk would a mouse, and which appeared to have only been seen at distant intervals. In the Persian literature it is called *Seemurgh;* and El Kazweenee, one of Mr. Lane's correspondents, speaks of the *anka*, the greatest of birds. Marco Polo also heard of a large bird during his travels, which the people of Madagascar call a *rukh*. "In form it is said to resemble the eagle, but it is incomparably greater in size, being so large and strong as to seize an elephant with its talons, and to lift it into the air, from whence it lets it fall to the ground, in order that when dead it may prey upon the carcase. Persons who have seen this bird assert that when the wings are spread they measure 16 paces in extent from point to point, and that the feathers are eight paces in length, and thick in proportion." The texts of the celebrated traveller, however, differ widely as to the size of the bird and the place which it inhabited. The measurements given above are the smallest stated. In one text it is said to inhabit Madagascar; and in another, certain islands which lay beyond Madagascar. It is not of much importance, perhaps, which is the correct version, since we find the locality assigned it in other accounts to be different. Thus, judging from what is said in the 'Arabian Nights,' we should conjecture the locality to be Sumatra, or some of the islands of the neighbouring archipelago. In an old map of the world constructed by Fra Mauro, the southern point of Africa is said to be the place where is found a big bird capable of trussing an elephant, and possessing great powers of flight. Whether these stories be founded on fable or fact, certain it is that oriental writers make frequent mention of a gigantic raptorial bird, and the question whether any such bird ever existed in the regions referred to naturally suggests itself.

It would be very rash to assert that the *Æpyornis* is the bird alluded to in any of these accounts; and it is doubtful if they all relate to the same bird. Nevertheless, it is as well these stories should be borne in mind, since there is unquestionably much that is common to the *Æpyornis*, and the gigantic bird of the East. St.-Hilaire was of opinion that the *Æpyornis* was a brevipennate or struthious bird; and if his opinion be correct, the *rukh* and the *Æpyornis* were certainly not identical. Duvernoy examined some bony fragments sent by M. Coquerel to France in 1854, amongst which was a portion of a tibia. He notices that this bone has a great analogy and even resemblance to the same part in the ostrich, but that there are, nevertheless, certain differences. It is more compressed in *Æpyornis* than in the ostrich; the common form of the articular surface is very different from the corresponding part of the ostrich. His opinion is that it belonged to a terrestrial bird which may have had well developed swimming powers. Valenciennes examined the bones, and thought they indicated natatory habits. He found the metatarsus to be widely different from the same bone in *Dromaius* and *Rhea*, but to have a strong resemblance to the metatarsus in the *Palmipedes*. This is shown by the length of the neck of the middle condyle, the obliquity of the pulley on which the outer digit plays, and by the groove on the anterior face of the bone, terminating in a rounded slope between the two condyles. On the internal face of each condyle is a small tuberosity, a disposition somewhat analogous to the hollow at the same spot on the metatarsus of *Palmipedes*. He thinks that *Æpyornis* ought, perhaps, to be placed in the penguin family. The largest egg described by St.-Hilaire had a long axis of 12·95 inches, a short axis of 9·03 inches, and a circumference, measured in a line with its long axis, of 35·45 inches; a second measured 13½ inches longitudinally, 8⅞ inches transversely, and 33½ inches the long circumference. An egg exhibited by Professor Tennant at a meeting of the Zoological Society in 1863 had a long circumference of 35 inches. This would be about twice the size lineally of the egg of the ostrich, or six times as large in bulk. Taking the egg as a basis, St.-Hilaire considers the *Æpyornis* was not more than 3·8 metres high. The osseous fragments are said to have been found in the same bed from whence one of the eggs were obtained, but there is no clear proof that the eggs and the bones belonged to the same species. Of the bones, only one has been of much use in determining the affinities of the bird to which it belonged. This bone has been carefully examined and compared by Bianconi with the corresponding bone of numerous other birds representing all the great avian orders; and the memoir in which these observations are given is really a monograph on the tarso-metatarsal bone in birds. The result of his inquiry is that the *Æpyornis* was a vulture, nearly allied to *Sarcoramphus gryphus*. If this opinion be correct, it thoroughly harmonises with what Marco Polo says of the *rukh*. If, also, the birds differed in size as much as do their tarso-metatarsi, perhaps even Marco Polo's measurements may be accepted as being little, if at all, exaggerated. The tarso-metatarsus of *Æpyornis* is five times as wide as the corresponding bone of the griffon; and if its expanse of wing was greater in proportion, the alar extent of *Æpyornis* would fall little short of 40 feet, and 16 paces would be about 40 feet.

Within the last few months M. Granddidier has discovered some more remains of the *Æpyornis* associated with the bones of a species of *Hippopotamus*, which will probably throw much light on its true affinities. Amongst the remains are a tibia, 25 inches in length; a femur of remarkably robust proportions, the diameter at one end being one-fourth the length of the bone; several vertebræ, and a fragmental egg. The association of the large bird with a large mammal, not living in the island now, is a remarkable fact.

The principal memoirs on this bird are those by St.-Hilaire in the 'Comptes Rendus' for 1851 and 1854; and by Bianconi, in the 'Memoirs of the Academy of Science at Bologna, Second Series,' vol. xii. (1862); and Third Series, vol. iii. (1863), and v. (1865).

AEROLITES [E. C. vol. i. col. 72—83]. During the last ten or fifteen years a large number of memoirs have been devoted to the subject of aerolites. As a slight illustration of the extent of this literature, it may be mentioned that the writer has before him a by no means complete list of papers (published since 1855), entirely devoted to aerolites and meteoric irons, which would fill five pages of this Cyclopædia. In addition to these there are many somewhat lengthy notices embodied in reports and papers which treat of other subjects besides Aerolites. On turning over this list the most frequently recurring names are Haidinger, Smith, Shepard, Greg, Maskelyne, Jackson, Newton, Rose, Damour, and Wöhler. Much good work, however, has also been done by Faye, Kieselmayer, Buchner, Harris, Pisani, Daubree, Cloez, Des Cloizeaux, Sorby, and others. Considering that all the aerolites and aerosiderites that have been discovered would not, if collected in one heap, form more than a very small hillock, it may be asked by some why there should be so much interest attached to apparently so insignificant a collection of fragmentary stones. A short answer to this question is that, with the exception of the light of the sun and stars, they are the sole representatives of non-terrestrial bodies whose examination affords good reliable evidence as to the composition of those bodies, and the only materials we have for studying planets in the same way as the earth is studied. The facts derived from the small heap of aerolites form the basis of *planetology*, by which name we would indicate a science analogous to geology. On the other hand, the following article may be considered an attempt to give a more lengthy answer to the same question.

The phenomena attending the fall of these bodies are so generally alike that the description of some three or four suffices to give a tolerably accurate idea of all. The famous fall at L'Aigle described in the Cyclopædia has been closely paralleled of late years by the fall at New Concord, Ohio, on the 1st of May, 1860. The latter began with a loud report, which was distinctly heard over an area of 150 miles in diameter; the point from which it appeared to come was over the southern part of Noble County, Ohio. It was followed by 23 detonations, a rumbling noise which lasted for two minutes, and then by a shower of stones over an elliptic area 10 miles in length and 3 miles in breadth. The stones varied from small fragments to a mass weighing 103 lbs., and penetrated the ground in an oblique direction to a depth of between 2 and 3 feet. All had a black crust and a bluish-grey felspathic-like interior, spotted with points of nickeliferous iron. On a comparison of the statements of various witnesses it has been estimated that the height of this meteorite was about 43 miles when passing over Noble County, that its course was from S.E. to N.W., and that its velocity was about 4 miles per second. According to Evans it was first seen over Washington County, about 39° 27′ N. lat., and 81° 8′ W. long., and last seen over Noble County about 39° 51′ N. lat., and 81° 34′ W. long. Upwards of 30 stones were collected; the smallest (8 oz. in weight) was found at the S.E. end, and the largest at the N.W. end of the area upon which they fell. People who saw the meteorite from a distance described it as being like a ball of fire which left a luminous track behind it. The only important point in which this fall differs from that of L'Aigle is in the greater size of the stones, and the position of the larger stones, which were at the S.E. end of the area of fall in one case and at the N.W. end in the other.

On the 26th of May, 1751, two masses of iron struck the earth near Hraschina, about 75 miles W. of Szigetvar, in Hungary. This fall is the same as that mentioned in column 82 of the Cyclopædia, and under IRON, E. C. From the documentary evidence not long since discovered by M. Haidinger, it seems that their fall was preceded by the appearance of a tortuous flame, which soon changed into a fire-ball with a tortuous chain-like tail. It passed from Neustadt to Hraschina in a south-easterly direction, and was probably between 40 and 50 miles high just before its fall, when its velocity being diminished by the resistance of the atmosphere it dropped to the ground. The pieces of iron weighed 71 lbs. and 16 lbs. respectively, but the latter has been lost. The former was the iron in which the crystalline structure was first seen by Alois von Widmanstätten, an iron master. He cut a slice from the iron and polished it in order to see how it would behave when heated. It was observed to pass through the usual shades of straw-yellow, brownish-yellow, violet, and blue; but there were also noticed groups of regular triangles formed by straw-coloured lines, which were so blended with others of blue and violet tints as to form a phenomenon of great beauty. Those figures are now known as Widmanstätten's, but are generally obtained by etching with an acid, such as nitric acid. If the evidence is to be depended upon, it would seem that in this instance the motion was from N.W. to S.E.

On the 7th of June, 1855, an aerolite fell at St. Denis Westram, near Ghent in Belgium, about 30 paces from a man and woman. Its fall was preceded by a noise like that of the rattle of carriages, but without any loud detonation. It penetrated the ground to a depth of 2 feet, and on being immediately dug up was found to be hot, and to yield a sulphurous odour. It had a bluish-black colour, weighed 700·5 grammes, and had a specific gravity of 3·29.

On Nov. 30, 1850, an aerolite fell close to the village of Shalka in Bengal. Its fall was seen by two persons, who state that it was preceded by a noise like thunder; and that it penetrated the ground in fragments to depths varying from 3 to 4 feet. It was probably very hot, since the surrounding soil had the appearance of burnt clay.

A fall of aerolites occurred on Dec. 27, 1857, at Quengyoak, near Bassein in Pegu. Three stones belonging to one aerolite were found 5 and 10 miles apart. The aerolite first appeared as an umbrella-shaped flame. At the termination of its visible path a loud report like a gun was heard, followed by a rumbling noise. An observer 200 miles S.E. of the spot where it fell describes it as being like a large star which rapidly increased to a size three times that of the moon, and leaving behind it a long tail. Haidinger concludes from various data that it had a height of from 80 to 100 miles; that its original cosmical course was from E.N.E. to W.S.W., which was changed to an E. and W. direction by the resistance of the atmosphere; that the pieces were separated by an explosion; that the fragments fitted each other; and that the detonation was heard at 100 miles, but not at 200 miles.

An aerolite which fell at Dhurmsala in the Punjaub on July 14, 1860, was accompanied by a very loud noise followed by numerous detonations like artillery discharges, which are said to have made the earth shake. Three witnesses saw a flame passing over the station from N.N.W. to S.S.E. after the first explosion had occurred. A great many stones were found which had penetrated the ground to a depth of 12 or 18 inches, and some of these when picked up are said to have so benumbed the fingers in consequence of their intense coldness as to oblige them to be dropped. The largest specimen weighed 320 lbs.

The phenomena which are common to almost all well observed aerolitic falls are the appearance of an apparently stationary cloud, a gliding luminous flame of a globular or comet-like form, a loud but short noise like a clap of thunder or the report of a cannon, a series of smaller detonations like the discharge of musketry, a rushing sound, and the fall of one or more pieces of stone or iron. The direction varies considerably, as will be seen by comparing the above-mentioned examples; the stones seldom penetrate more than 4 or 5 feet, even in loose soil; and they are sometimes hot and sometimes cold.

There is much variation in both the chemical composition and the general structure of these bodies, but they always contain elements which are found in terrestrial substances. These elements are for the most part those which form the larger portion of the outer crust of our globe, but they are somewhat differently combined. Moreover, as will be seen further on, there are certain terrestrial elements which are just as common in rocks and minerals, but which are comparatively rare or absent in the aerolites. Of the 59 or 60 elements known to the chemist, about 18 have been found in aerolites, viz., iron, nickel, cobalt, magnesium, aluminium, chromium, calcium, carbon, copper, manganese, oxygen, phosphorus, potassium, sodium, silicon, sulphur, titanium, tin; and in some cases antimony, arsenic, chlorine, hydrogen, lead. The most abundant are iron, nickel, magnesium, oxygen, silicon and phosphorus; while tin, antimony, and lead rarely occur, and then only in traces. If we exclude the last three metals, this list comprises nearly all the more abundant of the terrestrial elements having the smallest atomic weights.

Aerolites are generally divided into *meteoric irons* and *meteoric stones*, which although an artificial arrangement will be here adopted in considering their chemical composition and properties. The irons may themselves be grouped in three divisions, according as they are composed—(1), of iron without any stony admixture; (2), of iron mixed with grains of olivin; and (3), of iron associated with silicates, such as augite and olivin. By these last we may pass into the stones, some of which are largely composed of similar silicates, with a few grains of iron dispersed through them, while others contain no native iron.

In the following table the composition of several meteoric irons are given:—

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Iron . .	95·25	94·28	93·39	92·43	88·27	81·20
Nickel . .	4·15	7·18	1·56	6·27	10·81	15·09
Cobalt . .	·21	—	·25	·67	.46	2·56
Manganese .	—	—	—	—	·13	—
Copper . .	·04	—	·45	.06	·07	—
Tin . . .	·03	—	—	·01	—	—
Magnesium .	—	·650	—	—	·09	—
Calcium . .	—	.350	—	—	—	—
Silicium .	—	—	·38	·02	—	—
Carbon . .	—	—	1·69	·53	·04	—
Sulphur. .	—	tr.	·67	—	tr.	—
Phosphorus .	—	—	·18	·01	—	·09
Residue . .	—	—	—	—	—	·95

1, is an iron found at Bohumilitz in Bohemia in 1829. 2. Nebraska territory in 1856. 3. Niakornak in Greenland in 1850. 4. Seeläsgen near Schwiebus, in Prussia in 1847. 5. The Pallas iron, found by Pallas in 1772, at Krasnojarsk in Siberia. 6. Cape of Good Hope, near the Sunday and Bushman River.

The iron is never pure, but is always alloyed with a little nickel, and is generally associated with a small proportion of cobalt. The relative proportions of the iron and nickel vary, but in the majority of cases the two together form about 98 per cent. of the aerolite. There are two exceptions in the table, viz., Nos. 2 and 3. The first appears to be due to a misprint of 94 for 91, and the other is remarkable for the large proportion of carbon and sulphur which it contains. The specific gravity varies from about 7·0 in specimens containing the least nickel, to nearly 7·9 in those which contain the largest proportion of that metal. On comparing the densities of iron and nickel, as obtained by the metallurgist and chemist, with those of the meteoric irons, it may be inferred that their specific gravity is not greater in the aerolitic than in the terrestrial varieties. Suppose, for example, the Bohumilitz and Cape of Good Hope irons be compared with imaginary alloys having an analogous composition. The average specific gravity of grey cast iron is 7·1; of white cast iron, 7·5; and of malleable iron, 7·6; while the latter occasionally rises to 7·8 or 7·9. The specific gravity of nickel is 8·27, which is increased to 8·66 by forging.

It will be noticed that the specific gravity of meteoric iron does not exceed the limits through which the terrestrial iron ranges, although the former always contains more or less of the heavier metal nickel. In many respects it has some resemblance to ordinary malleable iron; and, generally speaking, is capable of being welded or converted into cutting instruments like it, although there are instances in which the meteoric iron has been too brittle to work. It is remarkable, however, that the specific gravity, the hardness, and brittleness of meteoric iron frequently vary considerably even in the same specimen. An example of this kind is afforded by the meteoric iron discovered at Newstead in 1827, but not removed from the spot of discovery until 1861. It was found in clay four feet below the surface of the ground, and weighed 32¾ lbs. It is a warty mass, 1½ feet in girth, joined to an acuminated extremity. According to Dr. Smith, its appearance is unlike that of any manufactured metal, and suggests the idea that the extremity which is now the smaller and more pointed first reached the earth in its descent, while the larger extremity shows the part least affected by the shock. It was cut in two, and the surfaces, when polished and treated with nitric acid, showed the Widmanstätten figures. These figures were smaller than is usually met with in meteoric irons. The specific gravity of the lobed portion was 6·19, and that of the pointed end 6·74; while the difference in hardness between the outer and inner parts of the metal was readily detected by means of a graving tool. This difference is attributed to the effects of sudden cooling, especially at the point, from contact with the surface of the earth. The etchings of the iron clearly indicate that the grain was much closer at the pointed end than in the middle of the mass; and parts of the iron were so brittle as to be easily powdered in an iron mortar. Its composition was—iron, 93·51 per cent.; nickel, 4·86; silica, ·91; and carbon, ·59.

In most irons a minute proportion of the iron and nickel, and probably all the phosphorus, are combined into a crystalline compound which is insoluble in acid, and which constitutes the great bulk of the residue left when the aerolite is dissolved in hydrochloric acid. It constitutes the mineral known as *schreibersite.* The carbon occurs partly in the free state as graphite, and partly combined with the metal, forming a carbide of iron, or with hydrogen and oxygen. The silicon is generally combined with the metal as silicide of iron. The sulphur is combined with iron, and forms a sulphide, which is generally the proto-sulphide Fe S, although this is frequently mistaken for the more basic sulphide *Pyrrhotin*, which rarely occurs in aerolites. The name *Troilite* has been given to this sulphide.

The more important points observable in these non-terrestrial irons are that they are quite unoxidised, that they contain an exceptionally large proportion of nickel, and that they have a well-marked crystalline structure. As some of the meteoric stones are also remarkable for containing very little oxygen we shall say nothing about the first point at present, but will notice some of the attempts made to imitate the crystalline structure. The most successful have been those of Daubree, but he has not yet obtained a perfect imitation. On simply fusing an aerosiderite in a clay crucible a mass was formed which although crystalline did not show the characteristic figures. When soft iron was fused along with nickel, proto-sulphide of iron and silicon, a highly crystalline mass was obtained, but without presenting any marked resemblance to the natural specimens. On adding about 5 or 10 per cent. of phosphide of iron and a little nickel to about 5 lbs. of soft iron, and fusing the mixture, there resulted a mass which when cooled, polished, and etched, exhibited a dendritic pattern amidst which fine, bright lines were dispersed in a reticulated form. A still better result was obtained with the irons formed by melting together such terrestrial rocks as lherzolite, hypersthene, basalt, and melaphyre. They resembled many siderolites both in structure and composition, containing like them nickel, chromium, and phosphide of iron. Since the peculiar crystalline structure appears to be dependent on the presence of iron, nickel, and phosphorus, it is generally supposed that the Widmanstätten figures are due to the phosphide of iron and nickel; but, according to some authorities, they are rather to be attributed to the concurrence of two alloys of nickel and iron having different degrees of solubility. However this may be, it is noticeable that these figures are not seen in the specimens which contain the largest proportion of nickel; while the Newstead iron, which according to the analysis contains no phosphorus, does show them.

In many meteorites the iron is in a spongy state, containing cavities filled with olivin, silicate of lime and iron, and a few other minerals. Sometimes the minerals can be readily detected with the naked eye or with a lens, but frequently nothing short of a chemical analysis, or examination with high microscopic powers, will indicate their presence. The Pallas iron is a good example of this group (or *siderolites*, as it has been called), and contains large well developed crystals of olivin; the specimen found at the Sierra de Chaco, Atacama, in 1862, consisting of a mixture of iron and stone, is a second example; and the breccia-like fragment of iron and stone found at Copiapo, in 1863, is a third. As this group comprises but few specimens, and these combine the characters of the siderites and aerolites, we will pass on to consider the latter.

The stones that fell in Harrison County, Indiana, on March 28, 1859, illustrate the general composition of most of the aerolites containing iron. Their mean specific gravity was 3·46. The magnet separated a powder formed of portions of them into 4·91 per cent. of nickeliferous iron, and 95·09 of earthy material. When the latter was treated with acid, it was resolved into a soluble portion comprising 62·49 per cent. of the whole, and into an insoluble portion, forming the remainder, or 37·51 per cent. The metallic portion had the composition shown in the first column below, and the earthy that shown in the second:—

Iron	86·781	Silica	47·06
Nickel	13·241	Oxide of iron	26·05
Cobalt	·342	Magnesia	27·61
Copper	·036	Alumina	2·35
Phosphorus	·026	Lime	·81
Sulphur	·022	Soda	·42
		Potash	·68
		Perox. Manganese	tr.

From this it appears they are composed of nickeliferous iron, phosphide of iron and nickel, sulphide of iron, olivin, augite and albite, in about the following proportions:—

Nickeliferous iron	4·989
Schreibersite	·009
Sulphide of iron	·001
Olivin	61·
Augite and albite	34·

The Guernsey aerolite of 1860 gave the following results as the composition of (1) its metallic portion, and (2) its earthy portion; while (3) indicates the proportions of the constituents:—

(1.)		(2.)		(3.)	
Iron	87·011	Silica	47·30	Nickeliferous iron	10·690
Nickel	12·360	Oxide of iron	28·03		
Cobalt	·421	Alumina	·31	Schreibersite.	·005
Copper	tr.	Magnesia	24·53	Sulphide of iron	·005
		Lime	·02		
Phosphorus	·012	Soda Potash	1·04	Olivin	56·884
Sulphur	1·080	Manganese	tr.	Augite	32·416

The meteorite that fell at Chantonnay, Aug. 12, 1812, is composed of nickel iron and silicates; the latter are in the proportion of 51·1 per cent. of olivin, 38·01 augite, and 10·01 labradorite. That which fell at Blausko in Moravia, Nov. 25, 1833, is composed of 20·13 per cent. of nickel iron, 2·97 sulphide of iron, ·63 chrome iron, 35·18 olivin, 33·89 augite, and 17·30 labradorite. The Utrecht stone of June, 1843, is a mixture of olivin, augite, oligoclase, nickel iron, and magnetic pyrites. The Klein-Wenden stone of Sept. 16, 1843, is a similar mixture to the last, but it contains labradorite in the place of oligoclase. The stone that fell at Bethlehem (New York), Aug. 13, 1859, closely resembles that of Klein-Wenden. The Montrejean stone of Dec. 9, 1858, contains 10·04 per cent. of nickel iron, 1·71 chrome iron, 5·72 sulphide of iron, 45·08 olivin, and 37·51 felspar and hornblende.

The following are examples of aerolites which contain no native iron. The Bokeveld stone, which fell Oct. 13, 1838; it is composed of 6·4 per cent. of nickel-iron sulphide, 1·11 chrome iron stone, 84·32 olivin, 5·46 undecomposible silicates, and 1·92 carbon and bituminous matters. The Kaba stone of April 15, 1857, is very similar to the last, in being mainly composed of olivin, and in containing carbonaceous matters. The Lontalac stone of Dec. 13, 1813, is also largely composed of olivin. The Chassigny stone of Oct. 3, 1815, consists almost entirely of olivin, and is, in this respect, almost unique. It differs from most aerolites in its pale yellowish tint. It forms the extreme of a series, the opposite end of which is formed by such stones as those of Juvenas and Stannern, which consist merely of anthophyllite and anorthite, while olivin is absent. Another remarkable example is the aerolite of Orgeuil. It is a black mass, remarkably porous, and of comparatively slight density, or 2·56. A number of minute shining crystals of pyrrhotin are scattered through it. It also contained a few crystals of breunerite or carbonate of magnesia and iron. But the most interesting compounds are the black matter and the water of combination. The former appears to be very similar to humus, which is a common ingredient in lignite and peat. In the Kaba and Bokeveld stones, the carbonaceous matter is different, being either amorphous carbon, or a bituminous substance analogous to scheererite or ozokerite; but the Alais stone also contains a humus-like substance. The Stannern aerolite which fell May 22, 1808, consists of 65·15 per cent. of augite, 34·92 anorthite, ·98 magnetic oxide of iron, and ·54 chrome iron. The Juvenas stone, which fell June 3, 1821, is composed of 62·65 per cent. of augite, 34·56 anorthite, ·60 apatite, ·25 titanite, 1·35 chrome iron, 1·17 magnetic oxide of iron, and ·25 magnetic pyrites. This is also nearly the composition of the Jonzac stone of June 13, 1819. The aerolite which fell at Bishopsville in South Carolina, March, 1843, is a very peculiar one, consisting mainly of a white mineral having the composition of 67·14 per cent. of silica, 1·48 alumina, 1·70 ferric oxide, 27·11 magnesia, 1·82 lime, and ·67 water; this answers to a silicate of magnesia with the formula $2MgO.3SiO_2$, and to which the name *chladnite* has been assigned. This mineral is also thickly scattered through one of the Ohio stones of May 1, 1860, which are described as being chiefly composed of a pearl-grey olivin, having imbedded in it snow-white specks of chladnite, points of nickelic iron, broad patches of pyrrhotin, and black grains of chromite. The St. Denis Westram stone of June 7, 1855, is somewhat analogous to that of Bishopsville. It is partly composed of a whitish pumice-like material, and of a second resembling a dark ash-coloured pearlstone. The latter has the following composition, according to Von Hauer.

Silica	57·66
Alumina	tr.
Oxide of iron	20·65
Lime	1·53
Magnesia	19·

This is a silicate of iron and magnesia, to which the name *Piddingtonite* has been assigned by Haidinger. The stone that fell at Bustee, near Goruckpor, Dec. 2, 1852, is specially remarkable for containing a yellow transparent sulphide of calcium in the form of cubic crystals, to which the name *Oldhamite* has been given. It is associated with several other minerals of unknown composition.

In almost every instance these remarkable bodies are covered on one or more sides by a shiny dark-coloured crust, whose thickness is variable, but never very thick. The form of the stone or iron is generally somewhat pyramidal, the crust invariably coats the larger end, and sometimes extends over the sides. The larger end is usually rounded, and marked with shallow pits; the lateral edges are frequently sharp, especially towards the narrower end, but are frequently more or less rounded towards the thicker end. This crust is generally thought to have been formed by the fusion of the surface of the meteorites by the intense heat generated during their passage through the air, and before they detonate.

In some cases, however, the crust may be formed after the detonation, as is exemplified by the Butsura stones which fell May 12, 1861, within a few miles of each other. Some of the fragments were entirely coated with an incrustation, while others were not. When brought together, however, they accurately fitted each other, indicating clearly that they originally formed but one stone. Hence it is inferred that some were separated from the parent mass under conditions allowing of the subsequent formation of a crust, while in the others those conditions were absent.

The structure of meteorites presents many exceedingly interesting phenomena. In most cases it strongly resembles the oolitic structure of many terrestrial rocks. A number of spherules with a radiated structure are thickly dispersed through a more compact base, which spherules appear as though they had been formed before the stone had consolidated. Thus in the Borkut meteorite the spherules have been split in two, and the parts slightly separated from one another. Sometimes they are surrounded by a shell of sulphide of iron, and dispersed amidst the base along with crystals having a similar composition to themselves. Not unfrequently small fissures filled with metallic iron traverse the stone, and even pass through the spherules so as to shift the relative positions of their parts, as in the phenomenon called a *heave* by miners. This structure, which has caused the meteorites possessing it to be distinguished as *chondritic*, has been carefully studied by Sorby. His remarks on the subject are so important that we quote them in full. The names in parentheses indicate the meteorites in which the appearance mentioned was more especially observed:—"In the first place, it is important to remark that the olivin of meteorites contains most excellent 'glass cavities,' similar to those in the olivin of lava, thus proving that the mineral was at one time in a state of igneous fusion. The olivin also contains 'gas cavities' like those so common in volcanic minerals, thus indicating the presence of some gas or vapour (Aussun; Parnallee). To see these cavities distinctly a carefully prepared thin section and a magnifying power of several hundreds are required. The vitreous substance found in the cavities is also met with outside and amongst the crystals, in such a manner as to show that it is the uncrystalline residue of the material in which they were formed (Mezo-Madaras; Parnallee). It is of a claret or brownish colour, and possesses the characteristic structure and optical properties of artificial glasses. Some isolated portions of meteorites have also a structure very similar to that of stony lavas, where the shape and mutual relations of the crystals to each other prove that they were formed *in situ*, on solidification. Possibly some entire meteorites should be considered to possess this peculiarity (Stannern; New Concord), but the evidence is by no means conclusive, and what crystallization has taken place *in situ* may have been a secondary result; whilst in others the constituent particles have all the characters of broken fragments (L'Aigle). This sometimes gives rise to a structure remarkably like that of consolidated volcanic ashes, so much, indeed, that I have specimens which, at first sight, might readily be mistaken for sections of meteorites. It would, therefore, appear that after the material of the meteorites was melted, a considerable proportion was broken up into small fragments, subsequently collected together and more or less consolidated by mechanical and chemical actions, amongst which must be classed a segregation of iron either in the metallic state or in combination with other substances. Apparently this breaking up occurred in some cases when the melted matter had become crystalline, but in others the forms of the particles lead me to conclude that it was broken up into detached globules while still melted (Mezo-Madaras; Parnallee). This seems to have been the origin of some of the round grains met with in meteorites; for they occasionally still contain a considerable amount of glass, and the crystals which have been formed in it are arranged in groups, radiating from one or more points on the external surface, in such a manner as to indicate that they were developed after the fragments had acquired their present spheroidal shape (Aussun, &c.). In this they differ most characteristically from the general type of concretionary globules found in terrestrial rocks, in which they radiate from the centre; the only case I know at all analogous being that of certain oolitic grains in the Kelloways rock at Scarborough, which have undergone a secondary crystallization."

There are many other points connected with these bodies which we had singled out for treatment, such as Daubree's experiments on the synthesis of aerolites; general deductions based upon the chemical composition of these wanderers from space: a comparison of the times when, and places at which, they have fallen; and the relation between the olivinitic aerolites and the olivine rocks of Norway, New Zealand, and elsewhere, as well as serpentine; but we must content ourselves with a general outline of Daubree's experiments, as being the most important. By melting down fragments of lherzolite, a rock consisting almost entirely of augite, along with crystals of olivin, in the presence of a reducing agent, a stony mass was obtained in which the iron had separated out as minute grains, which were attracted by the magnet. The mass presented the general features of an aerolite, and even some of their minute details. Another method of imitation was to melt silicide of iron in a crucible of magnesia. By heating a mixture of silica, magnesia, nickeliferous iron, and the phosphide and sulphide of iron, a triple phosphide of iron, nickel, and magnesium was obtained.

ALABANDINE, the name for manganese blende; not Alabaudine, as in the Cyclopædia. The same name was also given by Pliny to the carbuncles which were cut and polished at Alabanda. They were also called Alamandine, which term, in its modified form, Almandine, is applied by mineralogists to the iron-garnets. [Garnet, E. C., Almandine, E. C. S.]

ALAUDINÆ [E. C. vol. i. cols. 105, 106]. Alauda.

A. arvensis, the common Skylark. The wide range of this species across the great Europæo-Asiatic continent has been noticed in the E. C. vol. i. col. 106. Although well known, too little attention has been paid to the great variations which it presents in its size and the distribution of its colouring; and hence there is much uncertainty as to whether the species nearly allied to it in general appearance, and which occur in geographical areas contiguous to its own, are really distinct species, or simply geographical varieties. Several supposed species have been recently founded which have subsequently been admitted, after the examination of a large number of specimens, to be varieties only. This is well seen in the three species, *A. arvensis*, *A. cantarella* (Bonap.) and *A. cœlivox* (Swinhoe).

In North China, more especially in the neighbourhood of Pekin, *A. arvensis* appears to be represented by a variety which has a smaller body than the English bird, and yet the wings are longer; its colours are generally duller; and there is an absence of that olive-yellow tinge which occurs in English specimens; the crest also is much smaller. This form was separated by Mr. Swinhoe as a distinct species under the appellation of *A. pekinensis*, but subsequently he admitted it to be specifically identical with *A. arvensis*. The size of the Pekin bird is, in inches: length 7·5; wing, 4·7; tail, 3·1; and tarsi, ·9. This variety also ranges into Amoorland.

Farther south, or at Shanghai, and along the valley of the Yang-tse river, there is another form which is intermediate in character between the Pekin variety just noticed and *A. cœlivox*, which inhabits the southern parts of China. Swinhoe, referring to some specimens of this form, says that "they constitute an intermediate race, which might by analogy be expected to occur on the boundaries that divide the northern race from that of the south; and certainly, geographically speaking, the Yang-tse river may be considered the dividing line of the northern area of China from the southern. This bird may, perhaps, be regarded as a hybrid form between the two species, which in this locality may be supposed to meet. I could not discover any striking differences in the song of the Shanghai bird from that of *A. cœlivox*, nor yet from that of the Pekin lark. But in size and general appearance the three appear certainly distinct. The Shanghai species may be characterised as intermediate to *A. pekinensis* and *A. cœlivox*, with proportionately longer wings than either, and less crest than the latter. Its first primary quill is more nearly of a length with the second than in the Pekin lark." The length is 6·8 inches; wing, 4·2; tail, 2·8; and tarsi, ·9. The specimens from Formosa have the spots on the back larger, and the streaks on the breast much broader and more numerous than in those from the neighbouring mainland.

A. cœlivox occurs in the south of China, extending from Foochow to Canton, and probably into Formosa. In this form the plumage is of a much richer hue than that of either of the two foregoing species; the body is smaller, but the crest is more developed. Length, 6·5 inches; wings, 3·6; tail, 2·4; and tarsi, ·9.

The idea suggested that *A. cantarella* is a hybrid of the other two kinds of lark may, we think, be safely rejected, since there is no direct evidence in support of it, and it is quite contrary to ordinary experience for hybrid forms to occur in a distinct geographical area from both its assumed parents. The three kinds of lark should be regarded either as three distinct species, or as three varieties of the same species. In any case it is interesting to notice the gradation of characters perceptible as we pass from the northern to the southern birds—a gradation which appears to occur also amongst the larks of Europe, for specimens have been shot in England identical with those of Pekin, and others have been seen at Geneva and Florence identical with those of Shanghai; and probably specimens of *A. cœlivox* will be found in the south of Europe or north of Africa. A careful search for the minutest variations would not unlikely lead to the collection of such evidence as would settle the question whether these three distinct forms are or are not varieties of *A. arvensis*.

ALBERTITE, or, as it is frequently called, Albert coal, is a mineral which resembles the Boghead coal in chemical composition, and, like that substance, has been the subject of much litigation in the American law courts, and of discussion amongst geologists as to whether it is a coal or not. This is a point which cannot be settled so long as there is no precise and generally acknowledged definition for the term coal, and which will probably only be established by a thorough investigation into the chemical composition and origin of the various hydrocarbonaceous minerals, such as coal, bitumen, asphalt, and petroleum. Although the chemical evidence may be as important as the geological, we shall in this article confine ourselves to the latter.

The two principal localities of albertite are those which have been longest known. About 18 years ago a farmer at Mountgerald, near Dingwall, found a vein of coal-like substance in one of his fields, and used several cartloads of it as fuel. Two or three years after, or about 1850, a Mr. Duff discovered a similar substance (which he at once worked for fuel), in Albert county, New Brunswick. This latter deposit has been worked ever since, and is generally known as the Albert Coal Vein.

The New Brunswick locality is situated near the head of the Bay of Fundy, and within a few miles of the Petitcodiac river. The rocks of the district occur for the most part in long irregular strips or bands, which run in a N.E. and S.W. direction. The western shore of the Bay of Fundy is bordered by a fringe of pre-carboniferous rocks; farther inland is a broad band of lower carboniferous beds, which in its southern extension abuts upon the flanks of hills formed of Huronian strata; while still farther inland is the carboniferous limestone. The pre-carboniferous fringe lining the Bay of Fundy terminates northward in a bold rounded projection, around the end of which are the lower carboniferous strata, containing the vein of albertite. The lowest of these strata consist of pyroschists or shales saturated with bituminous matter, and capable of being used as fuel. The same shales are again met with a few miles off, at a spot where petroleum springs exist. Their thickness is about 1000 feet, and they abound in the fossil remains of fishes. Above them is a bed of sandstone, followed by a conglomerate about 200 feet thick, which is partly composed of fragments of albertite and bituminous shale. The beds above the conglomerate are red marl, bluish siliceous limestone, immense deposits of gypsum, red conglomerate and sandstone.

That portion of the carboniferous strata which is situated between the termination of the pre-carboniferous ridge on the S.E. and the Petitcodiac River on the N.W. is bent into an arch or anticlinal fold, the axis of which is directed towards N. 10° E. This axis passes through the Albert mines, and its northerly extension would, if continued, pass through the oil-wells already referred to. The dip of the strata on either flank of the fold is not great, but the crown of the arch has been much fissured and the shale much contorted. The albertite occurs in a fissure or vein which runs in nearly the same direction as the anticlinal axis, and is often vertical, though occasionally it inclines towards the N.W. at an angle of about 80°. The vein is very irregular along the line of its course, being shifted repeatedly to the south by a series of small faults, and varying in width from 28 feet to a few inches. The vein is also irregular in thickness when followed in a downward direction. Wherever it passes through a hard rock it is narrow, but where it passes through a soft one, it bulges out; and, generally speaking, it is wider in its lowest part than in its highest. That the deposit is not a bedded one is abundantly evidenced by the absence of a fire-clay floor, so characteristic of ordinary coal beds, and by the way in which it cuts through the conglomerate and nearly horizontal sandstone. Where the vein passes through the shales little branches of albertite are given off from it, and pass between the laminæ of the shales for a few inches.

In addition to the main vein there are two minor ones which cut it at an oblique angle, and which, like it, intersect the stratified deposits almost vertically. These two veins are parallel to a number of other fissures which intersect the rock in the same way. Wherever the conglomerate is well exposed it is seen to have a gentle dip and to be traversed by a series of vertical joints, two of which are filled with threads of albertite.

If now we pass to the Scotch locality, indications of precisely the same phenomena are seen there. The Ross-shire railway cuts through a hill called the Craig, a short distance to the north of Dingwall. The strata appear to be shale surmounted by sandstone, conglomerate, and boulder clay. The beds are much contorted, and the sandstone appears to be unconformable to the shale. The shale dips towards the N.W. on the one side of the cutting, and S.E. on the opposite, indicating an anticlinal fold with a strike running from S.W. to N.E. The sandstone and conglomerate above it dip towards the N. at the commencement of the cutting, and towards the S. at its end, showing that they also partake in the fold, the strike of their beds being E. and W. The veins of albertite run in a S.E. and N.W. direction through the sandstone and conglomerate, and vary in thickness from one to three inches. They are very numerous, 28 having been seen in the course of the cutting. These fissures appear to correspond to the minor series of veins in the Albert mine district, and suggest the idea that there may be a larger vein connected with them; which is rendered the more probable by the fact that in the boulder clay small pieces of coaly matter occur in remarkable abundance. The Scotch albertite is a black shining substance which breaks with a conchoidal fracture, becomes electrical when rubbed, and burns with a smoky flame. Similar veins of albertite, or of a substance resembling albertite, have been found at Memramcook, Westmoreland county, New Brunswick; at Huetamo in Mexico; in Ritchie county, Virginia; in the Quebec group of rocks in Canada; at several places along the south-eastern flank of Ben Nevis; and at Strathpeffer in Ross-shire. The Scotch albertite occurs in rocks belonging to the Old Red Sandstone series. It is very probable that albertite occurs in a good many other localities; since there are frequent allusions in geological works to a black combustible coal-like matter lining crevices in the strata, which seems to be very like albertite. In the Devonian and Silurian rocks of Canada, this substance is evidently the result of the oxidation of petroleum. There are certain strata abounding in corals which are permeated with a fluid petroleum; and in localities where these are exposed along their outcrops to the lengthened influence of the air, the petroleum is converted into a coal-like substance, which is apparently identical with the veins of solid hard carbonaceous matter in the Silurian rocks of Eastern Canada. In Sir W. Logan's 'Geology of Canada' (1863), p. 525, it is stated that "this substance has been observed at Quebec, Orleans Island, Pointe Lévis, Sillery, St. Nicholas, Lotbinière, Drummondville, Acton, the vicinity of the Chatte river in Gaspe, and many other places. It fills veins and fissures in the limestones, shales, and sandstones, and even in the trap rocks which traverse these. Sometimes it is found in buttons or drops, as described by Vanuxem, forming botryoidal masses. At other times it lines fissures, as is seen at Drummondville; and at Sillery, spread over a surface which had been previously encrusted with small crystals of calcite. The shrinking of the layer has here given rise to cracks, such as are sometimes seen in a coat of varnish. In other cases it fills fissures several inches in diameter, so that it has been mistaken for coal; and attempts have been made to work it at Quebec and elsewhere. The mineral is never, however, in true beds, like coal, but is always confined to veins and fissures which cut the strata, showing its deposition to have been posterior to the formation of the rocks."

In conclusion it may be stated as probable, (1) that albertite occurs in veins and not in beds; (2) that originally it was in a liquid state and identical with petroleum, since it not only occurs under similar conditions as that liquid, viz., in anticlinal faults, but it also actually contains petroleum enclosed in its cavities.

(Hitchcock, *American Journal of Science*, 2nd Series, xxxix., pp. 267—273; Anderson and Mackenzie, *Quarterly Journal of the Geological Society*, xix., p. 522.)

ALCA [E. C. vol. i. col. 110; and AUK, E. C. vol. i. col. 344]. Special attention has lately been directed towards one of the members of this genus, *A. impennis*, in consequence of the probability of the species having become extinct. If it does exist, it appears to be on the verge of extinction, for it has disappeared within the last century from all the places where it was once known to breed.

In 1697 it would seem to have been tolerably abundant in the island of St. Kilda; in 1758 the bird is said to be a rare visitant; while from 1821 onwards a few specimens only are recorded to have been seen anywhere in the neighbourhood of the British Islands. Some idea may be obtained of its rarity when it is stated that 15 guineas were paid for one of the specimens now in the collection of the British Museum. Many of the later specimens seen were more or less emaciated or dead. The last well-authenticated occurrence is, we believe, that of May, 1834, when a specimen was captured in Waterford Harbour, which, after living for about four months, was presented to the Museum of Trinity College, Dublin, where it still remains. In 1845 two are reported to have been seen in Belfast Bay. This is the last that seems to be known of it as a British bird. Proceeding to more northern countries, the evidence represents it as being abundant in the Faroe Islands up to about 1800, but nothing has been seen of it during the last thirty years. Our knowledge respecting its occurrence in Iceland is very full, mainly in consequence of Mr. Wolley having made an expedition for the especial purpose of ascertaining whether the bird was extinct or not. The results of the expedition are thus summarised by a writer in the 'Nat. Hist. Rev.' vol. v. p. 478 (1865):—Off the coasts of that island there were three skerries, each known by the name of "Geirfuglaskér," on all of which we may presume that it formerly bred. The first of these, lying to the south-east, was probably rendered desolate many years ago, no tradition of its having been occupied by the bird now existing among the natives of the opposite shore. From the second, one of the Vestmanneyjar, the gare-fowl has apparently been long driven. Though traditions of the bird lasted until a generation ago, it may be inferred with justice, that it had already become rare as far back as 1800. The last and best known gare-fowl skerry lying off Reykjanes was on clear evidence exceedingly unproductive of these birds for some part of the last century. In 1732 expeditions to this islet, which had been discontinued for 25 years, were resumed, and kept up for several seasons, till from some cause or other they again fell into disuse about 1760. In 1813 the crew of a Faroese vessel, becalmed near the skerry, made a descent upon it, and slaughtered a large number of gare-fowls. At the end of June, 1821, Faber, the well-known faunist of Iceland, set out for the rock with some companions, one of whom, Count F. C. Raben, a Dane, landed upon it, but whether the birds had already completed their season's work or what, it is certain that no examples of *Alca impennis* were seen. Yet this very same year two birds were shot on the shore of the mainland (as others had often been before), not very far off, so that the breed was still existing on this station. In the spring of 1830 a submarine eruption took place off Reykjanes, during which the skerry completely sank under water, and immediately after a colony of gare-fowls was discovered on another rock lying nearer the mainland, and known as Eldey. In the course of the next fourteen years their numbers annually became smaller, partly owing to the inroads made upon them at the instance of Icelandic merchants, who found opportunities of disposing of them in the ordinary course of their trade. Most of the specimens of skins and eggs now existing in various collections were obtained through this source. The last captures known to have been made were in June, 1844, and the specimens, two in number, are yet preserved in the Royal Museum of Copenhagen.

With respect to districts farther to the west, we have evidence that in Newfoundland these birds existed in swarms in the 16th, 17th, and 18th centuries, and that they were slaughtered in vast numbers every year. In the 19th century Anspach, Bonnycastle, and other local writers, report that the bird no longer existed in their district. In 1852, however, Col. Drummond Hay, an excellent ornithologist, reports the appearance of a specimen off the banks of Newfoundland, so that it is just possible a colony may be still existing somewhere in these western waters, one likely locality being the Virgin Rocks, situated on the N. W. side of the Great Bank.

Considering, then, how doubtful seemed the future opportunities of fully investigating the natural history of this species, it was a matter of regret, some years ago, that our knowledge of its osseous structure and physiological peculiarities was very imperfect, and that although about 64 skins and 60 eggs have been preserved, yet only a few bones were accessible to the student. The search made during the past few years has resulted in the discovery of several additional skeletons or parts of skeletons. Thus the bones of two individuals were found in kitchen-middens, at Meilgaard, in Jutland, and of a third in one at Havelse, in Zealand; a few fragments have been found in the kitchen-middens at Keiss, in Caithness; and several mummied specimens have been disinterred from the guano soil of Funk Island, off Newfoundland. From these materials Professor Owen has been able to describe a complete skeleton of this species in the 'Transactions of the Zoological Society,' vol. v. p. 317—335.

Numerous papers have been written on this subject during the last few years; but the reader will find pretty well all that is known in the papers by Steenstrup in the 'Naturhistorische Foren. Videnskabernes Meddelelser,' for 1855; by Newton, in the 'Ibis' for 1861; and in Owen's memoir already mentioned.

ALCYONARIA. One of the orders forming the Actinozoan class. An abstract of Milne-Edwards' arrangement of it is given under POLYPIFERA, E. C.; a definition of it will be found under ACTINOZOA, E. C. S.; and notices of a few of the forms under ALCYONIDÆ, E. C., and GORGONIA, E. C.

The *Alcyonaria* so closely resemble the *Zoantharia* in their general physiological structure that it is quite unnecessary to repeat the details here. The knowledge of the group has been mainly derived from a study of the hard parts which are readily preserved in museums, and hence most of the classifications hitherto proposed have been chiefly based upon the character of the skeleton. Of late years increased attention has been bestowed upon the living forms whereby much light has been thrown upon the functions and relative importance of the features observed in the hard parts. The principal points in which the *Alcyonaria* differ from the *Zoantharia* are, (1) that in *Alcyonaria* the parts are developed to the number of four or some multiple thereof; (2) that the tentacles are eight in number, arranged in one circle, and pinnated; (3) that the laminæ of the mesenteries are frequently, perhaps always, amalgamated, not separate as in the *Zoantharia*; and (4) that many genera have an aquiferous system ramifying through the cœnosarc or cœnenchyme and connecting the various polypes. In some of these points, however, that relating to development in multiples of four being one of the exceptions, there is, we believe, no hard and fast line of distinction. For amongst the *Alcyonaria* the pinnæ of the tentacles become so rudimentary as to appear as mere corrugations on the side of the tentacle; while the aquiferous system is not entirely unknown amongst the other orders of *Zoantharia*. The corallum is generally formed by spicules, either isolated or arranged in bundles, and it is rare to find them developed into a continuous layer, a feature which is the rule amongst the *Zoantharia*. It would seem that, generally speaking, hard parts are least developed in the lower organisms of this class, and are comparatively rare or imperfectly developed in the higher. It would be desirable to learn what are the influences which retard or promote the development of dermosclerites. Considering that in the development of the individual the hard parts are first cartilaginous, then porous, and lastly firm, it would be expected that inferiority of organisation would be associated with absence of hard parts; but apparently the reverse is the case. In the palæontological development of the *Zoantharia* the genera with the most compact hard parts prevailed in the earlier palæozoic period, while those with less compact hard parts flourished in mesozoic and cainozoic times. So few are the fossil species of *Alcyonaria* that we cannot say if anything corresponding to this is to be found in that order. But it may be asked, by way of suggestion, are the softer species more highly organised and of more recent geological appearance than those with hard parts? Can anything like a palæontological succession be traced from species with cartilaginous or horny parts to those which abound in calcareous matter, and from these to others with less and less calcareous parts, terminating in groups in which scarcely any is to be detected?

The aquiferous system seems to differ but little in the order, but it is well represented in the *Gorgonidæ*. In *Plexaura* there is a series of longitudinal canals running parallel with the main axis. One side of the canal is formed by the axis, and the other by the cœnosarc or the wall of the polype itself. At intervals in the fleshy wall are a number of pores which lead by more or less intricate passages through the cœnosarc and into the somatic cavities of the polype. The nutrient fluid is thus enabled to pass to all parts of the polypidom. In some of the *Gorgonidæ* the axis is grooved, which grooves correspond with the longitudinal canals; in others, however, the axis is not grooved. In *Briareum* the canals are not arranged in a longitudinal series round the axis, but are scattered without any apparent symmetry.

In this connection we would allude to the recent discovery of polymorphism in this order by Dr. Kölliker, thus presenting an interesting parallel to the polymorphism amongst the *Hydrozoa*. Most, if not all, the instances yet found, belong to the *Pennatulidæ*. The polymorphism consists in there being large individuals which carry on the work of digestion and generation, while other and smaller ones of an asexual nature, appear to be specialised for the purpose of expelling the water.

We will next notice some of the classifications proposed within the last few years. Greene's, as given in his 'Manual of the Cœlenterata,' does not differ widely from that of Milne-Edwards, E. C. vol. iv. p. 410, although the phraseology is not the same. He recognises four families, namely, (1) the *Alcyonidæ*, in which the corallum is sclerodermic, generally spicular, but without true calcareous thecæ; and in which the cœnosarc is fixed. (2) The *Tubiporidæ*, in which the corallum consists of a number of distinct corallites without any septa, and whose thecæ are united externally by horizontal plates arranged at distant intervals. As in the previous family the cœnosarc is fixed. (3) In the *Pennatulidæ* the corallum is sclerobasic, the tissue secretions sometimes present, and the cœnosarc free. (4) In the *Gorgonidæ* the corallum is sclerobasic; sulcate, and may or may not be accompanied by additional tissue secretions. The cœnosarc is shrub-like and attached by its expanded proximal extremity. This grouping mainly differs from that of E. C. in there being four, and not three, families. The fourth family is based upon Milne-Edwards' tribe *Tubiporinæ*.

In the fourth volume of the third series of the 'Annals of Natural History,' the following classification is proposed by Dr. Gray, which he wishes to be regarded as provisional only:—

Order I. SABULICOLÆ.

Coral tree symmetrical with a simple base, supported by more or less distinct calcareous spiculæ, and strengthened by a single elongate fusiform calcareous central axis. Living with the base sunk in the sand or mud of the sea coast.

Family 1. *Pennatulidæ.*

Body free; more or less fan-like, with a naked peduncle and a single central axis. The upper part with the polypes placed in transverse series on one side, rarely on all sides. Axis fusiform, elongate, cylindrical and quadrangular, calcareous, as long as the coral.

I. *Penniformes.* Coral pen-shaped. Polypes in transverse pinnules, placed on each side of the vertical surface of the central radius or stem.

Tribe 1. *Funiculineæ.* Coral elongate, linear, slender; pinnules small, crowded. *Funiculina, Virgularia, Lygus, Scytalium.*

Tribe 2. *Pennatuleæ.* Coral moderately broad, pen-shaped; pinnules broad, expanded. *Pennatula, Sarcoptilus, Pteromorpha, Pteroeides.*

II. *Claviformes.* Coral club-shaped, or leaf-like. Polypes scattered on one side (rarely on both) of the upper part of the club.

Tribe 3. *Kophobelemnoniæ.* Coral club-shaped, with the polypes only on one surface of the club, leaving the other bare. *Kophobelemnon.*

Tribe 4. *Veretilleæ.* Coral club-shaped. Polypes on all sides of the club. *Lituaria, Sarcobelemnon, Cavernularia, Veretillum.*

Tribe 5. *Renilleæ.* Coral expanded, foliaceous with a slender stalk. Polypes only on one surface of the expanded disk. *Renilla.*

Family 2. *Umbellulariadæ.*

Body free, umbellate, with a long stem and a single central axis. The upper part with a cluster of polype-bearing cells placed in concentric series forming a large head. Axis fusiform, elongate, as long as the stem of the coral. *Umbellularia.*

Order II. SPONGICOLÆ, or HYALOPHYTA.

Subsymmetrical, living sunken by the base into a sponge, strengthened by siliceous spicula, and supported by a central axis formed of numerous twisted, elongated siliceous fibres, the lower end of which axis tapers and is parasitically embedded in a fixed sponge. The animal matter or bark is strengthened by siliceous spicules similar to but shorter and thinner than the fibres of the axis. The fibres are formed of numerous thin concentric layers.

Family 1. *Hyalonemidæ.*

Hyalonema.

Order III. RUPICOLÆ.

Coral tree-like, or expanded, fixed by an expanded base, supported by more or less abundant fusiform calcareous spicula, and often supported by a central calcareous or horny tree-like axis, with an expanded base. Living attached by the base of the coral and axis to rocks on the sea shore.

Suborder I. *Lithophyta.*

Coral arborescent, supported by a continuous or jointed calcareous axis, which effervesces with hydrochloric acid.

† Axis continuous, not jointed.

Family 1. *Coralliadæ.*

Axis inarticulate, solid, calcareous. Bark granular, with irregularly shaped spicula.

Corallium, Annella, Ellisella (including *Juncella* and *Ctenocella*), *Gorgonella, Scirpearia, Umbracella, Subergorgia.*

Family 2. *Primnoadæ.*

Axis inarticulate; solid. Bark formed of flat imbricate scales. Polype cells prominent, covered with imbricate scales.

Primnoa, Callogorgia, Primnoella.

†† Axis articulated.

Family 3. *Melitæadæ.*

Axis spongy, permeated by flexuous tubular canals interrupted by harder swollen calcareous joints. Bark granular; cells in series on the edge of the branchlets.

Melitæa, Mopsella, Solanderia (?).

Family 4. *Isideæ.*

Axis calcareous, solid, divided by narrow, horny joints. Bark granular, with irregularly shaped spicula.

Isis, Isidella, Mopsea.

Suborder II. *Ceratophyta.*

Coral arborescent, supported by a continuous (or jointed?) horny axis, which does not effervesce in hydrochloric acid.

Family 1. *Gorgoniadæ.*

Bark granular, persistent, with sunken, irregular-shaped spicula, with a more or less distinct groove down each side, and with the cells in series on each side of the branchlets.

* Coral arborescent or reticulated ; cells inside of the branchlets.

Gorgonia. Arborescent ; branchlets sub-compressed ; cells on side, moderate.
Pterogorgia. Arborescent ; branchlets much compressed ; cells minute, on edge.
Rhipidogorgia. Reticulated, fan-like ; cells on sides.

** Coral frondose ; cells on surface of frond.

Hymenogorgia. Axis branched, filiform ; branches separate.
Phyllogorgia. Axis branched, filiform ; branches netted.
Phycogorgia. Axis expanded, foliaceous, thin.

Family 2. *Plexauridæ.*

Bark granular, persistent, cork-like, without any impressed lateral grooves. Cells placed equally on all sides of the branches.

Plexaura. Cells not raised, simple.
Rhinogorgia. Cells not raised, bounded by a conical process.
Eunicea. Cells more or less produced ; simple.
Gonidora. Cells convex ; mouth radiated.

Family 3. *Muriceidæ.*

Bark composed of large imbricate calcareous spicula, without any lateral grooves, cells equally on all sides of the branchlets.

Muricea, Plocmus ?

Family 4. *Acanthogorgiadæ.*

Bark thin, formed of slender filiform spicula, without any lateral grooves. Cells campanulate, on all sides of the branches, with ridges of elongated spicula, and with a number of elongate setaceous spines on the margin.

Acanthogorgia.

(?) Family 5. *Antipathidæ.*

Bark fleshy, easily deciduous, soft, simple, only strengthened by large and small scattered, siliceous (?) plates.

Leiopathes, Antipathes.

Family 6. *Sarcogorgiadæ.*

Bark fleshy ; when dry skin-like ; smooth, without spicula ; the edges of the cells strengthened with granular spicula.

Sarcogorgia.

Suborder III. *Sarcophyta.*

Coral arborescent, lobulated or expanded, only strengthened by internal or external calcareous spicula which effervesce in acid.

Family 1. *Briareidæ.*

Coral arborescent, fleshy, supported by a central axis formed of numerous intertwined fusiform spicula.

Briareum.

Family 2. *Alcyoniadæ.*

Coral arborescent or lobed, fleshy, strengthened with imbedded calcareous spicula. Cells simple. Polype retractile or semi-retractile.

Alcyonium, Sympodium, Ammothea.

Family 3. *Xeniadæ.*

Coral expanded or arborescent, fleshy, soft, creeping or branched. Polype elongate, subcylindrical. Tentacles not retractile.

Xenia, Anthelia, Rhizoxenia, Evagora, Cornularia.

Family 4. *Nephthyadæ.*

Coral arborescent or expanded, fleshy, membranaceous, often very cellular. Cells of the polypes covered externally with large fusiform calcareous spicula.

Nephthya, Alyconidia, Nidalia, Clavularia.

Family 5. *Tubiporidæ.*

Coral calcareous, tubular. Tubes united by transverse plates, formed by the expanded edge of the tubes bearing the buds. Polype cylindrical.

Tubipora.

This classification, it will be seen, is very complicated : for whereas Milne-Edwards and Greene, consider the *Alcyonaria* to be formed of but one order with three or four families, Dr. Gray divides it into three orders and eighteen families. The principal distinctive characters of the orders is difference of habitat. If these orders are natural groups of the importance indicated by their name, we should expect them to be distinguished by important structural differences ; and if so, surely these should have been employed in marking off the groups. It is very doubtful if the *Spongicolæ* can be accepted as an order, and it seems probable that they do not even belong to *Alcyonaria.* Discarding this order, the definitions of the remaining two do not appear to us to be sufficiently distinctive. Gray's *Sabulicolæ* differs but little in extent from the *Pennatulidæ* of E. C. ; while his *Rupicolæ* answers to the *Alcyonidæ* and *Gorgonidæ.* The most striking differences between the two groups are due mainly to external form. In the one, the main axis extends from end to end, without dichotomous ramification : and the polypes are situated on offshoots which are arranged more or less symetrically on one or more sides of the main stem. They do not adhere to rocks, but are kept in position by the insertion of their bases in a soft sea bottom. In the other group the dichotomous arrangement is more or less apparent. This difference is, no doubt, dependent upon the mode of gemmation prevalent in each group.

The evidence respecting the position of *Hyalonema* is very conflicting at present. This genus, or rather the family, *Hyalonemidæ,* formed for it and a second genus named *Hyalochæta,* was the subject of an elaborate monograph by Brandt. Both he and Dr. Gray concurred in believing *Hyalonema* to be a coral nearly allied to *Gorgonia;* Leuckart considered it to be a sponge bearing a parasitic polype. Dr. Gray's view seems to be that it is a polypidom bearing a parasitic sponge belonging to the genus *Carteria,* but Stimpson had some specimens given to him which were unquestionably portions of widely different beings, artificially arranged into curiosities by the Japanese. Bundles of long siliceous fibres, such as those yielded by the beautiful sponge *Euplectella,* were cemented together with gum, their ends tied round with silk, and fragments of coral were inserted here and there in crevices. It is possible that these are, however, themselves imitations of natural products. For specimens corresponding in most points to those described by Brandt, have recently been obtained from deep water off the Portuguese coast. The animal is common, and well known to the fishermen, but it was not until 1864 that a single dried specimen found its way into the hands of a naturalist. M. Bocage described this specimen as still retaining its fish-like smell when he obtained it. It was composed of an axis formed of long hyaline fibres, and a polype-bearing coating, which partly covered the axis. The full length of the specimen was rather over two feet, but the polype-bearing crust covered less than half of it. Bocage expressly says it showed no indications of being parasitical ; and that the polypes were closely packed and arranged in irregular longitudinal and spiral lines. The majority of them were about one-fourth of an inch long, about one-sixth or one-seventh of an inch wide, and about one-ninth of an inch high. The polypes had 40 tentacles arranged in two circles ; the base of those in the inner circle corresponding to the spaces between those in the outer circle. And within these there were also a number of small conical tubercles which looked like rudimentary tentacles. The tentacles were triangular, compressed on two sides ; their edges were smooth, and they terminated in soft rounded points. The filaments of the axis varied considerably in size, and were formed of several concentric layers. Soon after this specimen was described, several others were obtained from the same locality. The examination of these confirmed the accuracy of Bocage's earlier observations, and tended still more to convince him that the polypes were not parasites. His reasons for this belief are thus stated by him : The cohabitation or simultaneous existence upon the same axis of polypes and sponges which has been noticed in some Japanese specimens, does not occur in those of Portugal. In these last, the polypiferous crust envelopes the axis in a uniform manner ; it entirely covers the straightest end of the axis ; and from thence extends uninterruptedly for two or three-fifths of the total length. The polypiferous crust and the polypes are formed of several tissues superposed in layers, in which we find a large number of siliceous spicules, whose morphological characters vary in each layer. The outer surface of the crust has a rough granular aspect, which is due to the presence of small regular spicules with numerous points, and which form an essential part of the integument. Notwithstanding Bocage's arguments, we should not be surprised to learn, that both the Japanese and Portuguese species of *Hyalonema* are parasitical, for the descriptions given of these remind us strongly of *Gerardia* amongst the *Antipathidæ,* which is now known to be parasitical, and to build up in its internal axis, the fibres of sponge. The descriptions of Brandt and Bocage suggest strong doubts as to whether the *Hyalonema* is really an *Alcyonaria*. The Japanese species have 20 tentacles, and that of Portugal 40; from which it would seem the structural plan of development is in multiples of 5. Moreover, the tentacles are smooth and not pinnated. Dr. Bowerbank has claimed the genus as belonging to the Sponge, and his principal argument for assigning it that position is that siliceous particles are secreted only by Protozoans. It does not follow, however, that everything found in the tissues of an Actinozoon has been secreted by the organism itself; thus *Zoanthus* incorporates particles of sand in its outer coating; *Gerardia*, as before mentioned, adopts the siliceous fibres of sponge, the siliceous spiculæ of *Gorgoniæ* and other objects; and indeed, a similar habit will probably be found amongst yet other Actinozoon genera. *Hyalonema*, then, seems to belong neither to the sponges, nor to any of the orders of Actinozoon, as at present constituted; but it certainly seems to be an Actinozoon of some kind. The question has been rendered more complicated by the description of a new species by Semper, which he assigns to the genus *Hyalonema*. This appears to be a sponge allied to *Euplectella*, but it has no generic relationship with what Gray and Brandt originally called *Hyalonema*. The reader is referred to numerous papers on this subject in the 'Annals of Natural History,' 4th Series, vol. i. In one of these papers Dr. Gray makes the family consist of two genera, viz.:—*Hyalonema* and *Hyalothrix*, the latter being founded on the *Hyalonema lusitanica* of Bocage. The recent dredging expeditions by Drs. Carpenter and Wright have resulted in the discovery of numerous specimens of a species of *Hyalonema* (Semper), which afford spiculæ precisely like those found in the axis of the Actinozoan *Hyalonema*.

There is another group, viz., the *Antipathidæ*, which Dr. Gray has placed in the present order, but the structure of their soft parts is decidedly indicative of their Zoantharian affinities; and, indeed, most authors regard them as *Zoantharia*.

The classification proposed by Duchassaing and Michelotti is based upon a prolonged study of the living species of the West Indies, and upon the structure of their soft parts.

They adopt the characters of the tegumentary system for distinguishing their principal groups. The same characters were used by Milne-Edwards and Haime in classifying the *Zoantharia*, and Duchassaing and Michelotti find the *Alcyonaria* naturally fall into similar groups. Accordingly they have given them similar names. Subsidiary groups are based upon the lateral, basal, or mixed character of the gemmation. The following is their linear arrangement.

	Malacodermata.	Sclerodermata.		Sclerobasica.	
		Gorgonidæ.	Pennatulidæ.	Cornularina.	Tubiporina.
Basal gemmation.	Anthelia.	Primnoa.	Pennatula.	Haimeia.	
	Sympodium.	Thesea.	Sarcoptilus.	Cornularia.	Tubipora.
	Ojeda.	Muricea.	Virgularia.	Clavularia.	
		Acis.	Pavonaria.	Rhizoxenia.	
		Blepharogorgia.	Umbellularia.	Sarcodictyon.	
		Eunicea.	Lituaria.		
Lateral gemmation.	Alcyonium.	Plexaura.	Veretillum.	Telestho.	
	Sarcophyton.	Gorgonia.	Cavernularia.		
	Ammothea.	Leptogorgia.	Renilla.		
	Spoggodes.	Lophogorgia.			
	Paralcyonium.	Pterogorgia.			
	Cœlogorgia.	Villogorgia.			
	Paragorgia.	Xiphigorgia.			
	Briareum.	Rhipidogorgia.			
		Phyllogorgia.			
Compound gemmation.		Hymenogorgia.			
		Hypnogorgia.			
		Chrysogorgia.			
	Xenia.				
		Gorgonella.			
		Juncella.			
		Verrucella.			
		Ctenocella.			
		Riisea.			
		Isis.			
		Mopsea			
		Melithea.			
		Solanderia.			
		Corallium.			

Kölliker has subjected this group to a thorough examination from a histological point of view, and the following classification is one of the results of his labour:—

Family I. *Alcyonidæ*, M. E.

Sub-family 1. *Cornulariadæ*, M. E.
Genera: *Clavularia*, Q. and G.; *Anthelia*, Sav.; *Rhizoxenia*, Ehr.

Sub-family 2. *Alcyoninæ*.
Genera: *Alcyonium*, L.; *Ammothea*, Sav.; *Xenia*, Sav.; *Nephthya*, Sav.; *Spoggodes*, Less.

Family II. *Pennatulidæ*, M. E.

Genera: *Funiculina*, Lam.; *Pennatula*, L.; *Pteroeides*, Heckl.; *Veretillum*, Cuv.; *Cavernularia*, Val.; *Renilla*, Lam.

Family III. *Gorgonidæ*, M. E.

Sub-family 1. *Gorgoninæ*, M. E.
A. *Primnoaceæ*, Val.
Genera: *Primnoa*, Lamx.; *Muricea*, Lamx. (*pro parte*); *Echinogorgia*, Köll.; *Paramuricea*, Köll.; *Acis*, Duch. et Mich.; *Thesea*, Duch. et Mich.; *Bebryce*, Phil.
B. *Euniceidæ*.
Genera: *Eunicea*, Lamx.; *Plexaura*, Lamx. (*pro parte*); *Plexaurella*, Köll.
C. *Gorgonaceæ*, M. E. (*pro parte*).
Genus: *Gorgonia*.
D. *Gorgonellaceæ*, Val.
Genera: *Gorgonella*, Val. (*pro parte*); *Juncella*, Val. (*ex parte*); *Verrucella*, M. E. (*ex parte*); *Riisea*, Duch. et Mich.
Sub-family 2. *Isidinæ*.
Genus: *Isis*.
Sub-family 3. *Briareaceæ*, M. E.
Genera: *Paragorgia*, M. E.; *Sympodium*, Ehr.; *Erythropodium*, Köll.; *Briareum*, Bl.; *Solanderia*, Duch. et Mich.
Sub-family 4. *Sclerogorgiaceæ*, Köll.
Genus: *Sclerogorgia*, Köll.
Sub-family 5. *Melithæaceæ*.
Genera: *Melithæa*, *Mopsea*.
Sub-family 6. *Corallinæ*, M. E.
Genera: *Corallium*, Lam.

Verrill's classification may be thus briefly represented:—

Sub-order I. *Alcyonacea*. Families: *Alcyonidæ*, *Xenidæ*, *Cornularidæ*, *Tubiporidæ*.

Sub-order II. *Gorgonacea*. Families: *Gorgonidæ*, *Plexauridæ*, *Primnoidæ*, *Gorgonellidæ*, *Isidæ*, *Corallidæ*, *Briaridæ*.

Sub-order III. *Pennatulacea*. Families: *Pennatulidæ*, *Pavonaridæ*, *Veretillidæ*, *Renillidæ*.

ALGODONITE (Cu_6As). A brilliantly silver white arsenide of copper, occurring in lumps and veins in the silver mine of Algodon, near Coquimbo, in Chili. From its appearance it was at first thought to be silver, but an analysis by Field showed that it consisted of 83·30 parts copper, 16·23 arsenic, and 0·31 silver. It somewhat resembles Domeykite, but differs from it in containing a much larger proportion of copper. It also resembles Whitneyite in many of its physical characters, but may be distinguished by its coarser granular structure and its deeper greyish-white tint. Under certain circumstances, whitneyite is gradually converted into algodonite. Algodonite has a sub-conchoidal fracture, and a specific gravity of about 7·60.

ALLEMONTITE. An arsenide of antimony found at Allemont, in the department of Isère, and also at Andreasberg, Przibram, and other localities. It occurs in veins in gneiss generally associated with native antimony and antimony ores. It resembles native arsenic in appearance, and is of a tin-white colour, with a faint lustre. Rammelsberg gives as its composition 62·15 per cent. of arsenic, and 37·85 of antimony, from which it would appear that the two metals are not combined in atomic proportions. (Watts, *Dict. of Chem.* i. p. 371.)

ALLOCHROITE. A variety of iron-lime garnet, belonging to the same group as melanite, or the black garnet, and the common garnet. It is distinguished from almandine by its opacity, by its redness being grey and dingy, and by the variety of its colouring, whence its name from ἄλλος, other, and χροιά, colour. It occurs in an iron mine at Drammen, Norway.

ALLOPHANE. This substance has been analyzed by several persons since that made by Stromeyer was published, and amongst others by Bunsen, Walckner, Berthier, Guillemin, and Northcote. Disregarding the foreign admixtures, it is said to nearly agree with the formula $Al_2O_3.\ 3SiO_2+15H_2O$, but when they are taken account of, it varies greatly in composition. In a specimen from a lignite bed near Bonn, Bunsen found carbonates of lime and magnesia, but no copper; while Schnabel has analysed several containing from 14 to 19 per cent. of oxide of copper. A specimen from Woolwich, analysed by Northcote, gave—

Silica	20·50
Alumina	31·34
Protoxide of iron	0·31
Lime	1·92
Carbonic acid	2·73
Water	42·91
	99·71

It dissolves readily in dilute acids, and deposits gelatinous silica when treated with concentrated acids. It occurs in the chalk pits at Charlton, near Woolwich, in the chalk at Beauvais, France; at Richmond, Massachusetts, at the Bristol copper mine, Connecticut, in the United States, and at several other places. It usually occurs as a lining to the small cavities in marl or chalk. (Bristow, *Glossary of Mineralogy*; Watts, *Dictionary of Chemistry*.)

ALMANDINE. This is an alumina-iron garnet, that is, a silicate of alumina and iron, as will be seen by reference to the analysis given under Garnet, E. C., and not a silicate of alumina and magnesia, as stated under Almandine, E. C. This variety of garnet occurs in Ceylon, Pegu, Greenland, Hindostan, Brazil, at Ala in Piedmont, in various parts of Bohemia, at Elie, in Fifeshire, Killiney and Wicklow in Ireland, and in the United States.

ALSTONITE, a mineral having the same composition as baryto-calcite, but a different crystalline form. It occurs in right rhombic prisms, while baryto-calcite crystallizes in the oblique system. It was called *Bromlite* by Thomson, from its supposed locality, Bromley Hill, near Alston; it really occurs at Brownley Hill mine, and at Fallowfield, near Hexham.

ALTAITE, a telluride of lead (Pb. Te.) found in the Savodinsky mine, near Barnaoul, in the Altai Mountains. A specimen, analysed by G. Rose, gave: lead, 60·35; tellurium, 38·37; and silver, 1·28. It usually occurs in massive granular lumps; but occasionally in cube-shaped crystals. When the surface is fresh the colour is tin white, and the lustre metallic. Its hardness is about 3 or 3·5, and its sp. gr. 8·10.

ALUM SLATE, or SCHIST, is a rock intermediate in character between clay slate and mica schist. Its principal characteristic is that it is largely permeated by bituminous matter and iron pyrites. So abundant is the former, that in Sweden, where the alum schist is employed as a source of alum, and where wood is scarce, the schist itself is used as fuel in calcining the rock and in evaporating the alum liquors. It is not confined to any one geological formation, but the bed at Hurlet forms part of the coal measures, and immediately overlies a seam of coal. The following is the result of an analysis of the shale made by Wilson. ('Phil. Mag.' [4] ix. p. 417):

Silica	48·28
Alumina	26·96
Protoxide of iron	3·72
Lime	2·38
Magnesia	tr.
Potash	.24
Bisulphide of iron	11·13
Water	2·02
Carbon	3·98
Hydrogen	1·07
Nitrogen	·62
	100·4

There is no alum in the schist itself, but this substance is formed by the processes to which it is subjected. [See Alum, E. C., A. & Sci. Div.] Hence the name is not an appropriate one, since almost any aluminous substance—common clay, for example—will yield alum by a somewhat similar treatment.

There is another substance long used as an alum ore, viz., the *alum-stone* or *alunite* of Tolfa in Italy, Mount Dore in Auvergne, and Elizabethpol in Georgia. This does contain a native potash alum, which has already been noticed under Alum-Stone, E. C. The following analyses by Mitscherlich are given below as being more recent than Cordier's; 1 is the composition of crystals from Tolfa, and 2 of some from Muzsai, Hungary:—

	(1.)	(2.)
Alumina	36·83	39·15
Sulphuric acid	38·63	36·93
Lime	·70	·49
Potash	8·99	10·67
Barytes	·29	·19
Soda	1·84	—
Water	12·72	12·57

ALUNOGENE. ($Al_2O_3\ 3\ SO_3 + 18\ H_2O$), a mineral closely allied to *Aluminite*. The latter is a hydrated subsulphate of *Alumina* ($Al_2O_3\ SO_3 + 9\ H_2O$), while the subject of this article is a hydrated tersulphate of *Alumina*. It occurs in fibrous masses, white when pure, but yellowish or reddish when impure. It is translucent, and has a silky lustre. The hardness is about 1·5 or 2, and the specific gravity 1·6 or 1·8. It appears to be formed from iron pyrites in the presence of clays, but it is also said to be formed by volcanic action. It occurs in numerous localities, as for instance at Arraya, near Cumana; Socono; Copiapo, Chili; Adelaide, New South Wales; at Vesuvius, associated with alum; and at Smoky Mountain, Jackson County, Carolina. (Bristow, *Glossary of Mineralogy*.)

AMBER. No doubt is now felt as to amber being the product of extinct *Coniferæ*, since it has been found encrusting and penetrating fossil wood, enclosing cones and leaves, and, indeed, occurring under precisely similar circumstances as the existing resin. The tree which seems to yield it in the greatest abundance, has been named *Pinites succinifer* by Goeppert. Its distribution is far more extensive than seems to be implied in the Cyclopædia article. Its principal area is the Western part of Europe, throughout which it is apparently restricted to various deposits of sand and clay of early tertiary age; it has frequently been reported as occurring in the lignite beds of North Germany, but the substance so found is *retinite*, not amber, according to Goeppert. It is probable that all the amber washed up on the shores of the countries bordering the Baltic and North Seas, was originally deposited in beds of a similar age. This question of age is of importance, since it involves that of the amber pine forests which formerly existed in Europe, and which appear to have had some connection with the sea which many geologists believe to have connected the Baltic with the Mediterranean. Amber is of especial interest on account of the beautiful preservation of the organic remains it incloses. Upwards of 800 species of insects have been found in amber, most of which are said to be extinct. The remains of plants contained in the amber, also indicate a varied flora. Some idea may be formed of the richness of the former, from the following summary published by Tasche in 1860,—

	Genera.	Species.
Crustaceans	3	5
Myriapoda	11	33
Arachnidans	73	205
Insects: Aptera	9	24
„ Hemiptera	23	60
„ Orthoptera	4	8
„ Neuroptera	44	87
„ Diptera	94	600
	261	1022

Since then there have been numerous additions. Thus, in 1864, Loew was acquainted with 850 species of *Diptera*, nearly all of which belong to the proboscidean division. His remarks on them have especial interest in connection with the physical geography of the time. The amber fauna he believes to be a fragment of a larger fauna, and to consist chiefly of those species which frequent moist shady places in woods, sluggish waters, such as ponds and slowly flowing streams, and rotting wood; while those which frequent open sunny spaces, are very rare. It indicates a climate probably somewhat warmer than at present, and is most nearly related to the *Diptera* of Western Europe and North America; but there is a closer connection with the *Diptera* of North America than with those of Europe. This would seem to indicate that since the time of the amber fauna there has been a more or less complete connection between the European and American continents in temperate, or at least not very high northern, latitudes. Goeppert has some remarks on the amber flora in the 'Zeitschrift d. Deutschen Geologische Gesellschaft,' xvi. p. 189. (1864.)

Amber, however, is by no means confined to Europe, for it has been discovered in many parts of Asia, from the shores of the Caspian Sea through Siberia, China and Kamtschatka, and onwards into North America; it is also said to occur in India and Madagascar.

Amber is distinguished from mellite and copal, which are vegetable resins frequently substituted for amber, by being fusible, whereas mellite is not; and by melting into drops which rebound from the hard surfaces on which they are allowed to fall, whereas those of copal flatten as they fall.

Of the more recent papers known to us, that which gives the clearest idea of the stratigraphical position of the amber beds of Europe, is by Dr. Zaddach, in 'Schriften der Physikalischœkonomisch Gesellschaft zu Königsburg,' vol. i. p. 1. a full abstract of which will be found in vol. v. of the 'Quarterly Journal of Science.' His remarks refer to the north coast of Samland, one of the Prussian provinces bordering on the Baltic Sea. He describes two sets of beds of tertiary age, the lower being called the glauconitic sand group, and the upper the brown coal formation.

The *amber earth*, or the stratum containing the amber in greatest abundance, is the lowest exposed part of the glauconitic series. The amber is in pieces, having an average weight of somewhat less than a pound. They are slightly rolled, indicating a short exposure to water and friction. Associated with these are bits of wood, and, rarely, whole trees and large portions of them. Some of the wood is thoroughly permeated with the amber. In this stratum and in the quicksand overlying it have been found 35 species of fossils, which number is, of course, exclusive of those which are met with *in* the amber itself. The most abundant are *Ostrea ventilabrum*, *Cardium vulgatissimum*, *Pectunculus polyodontus*, *Natica Nysti*, *Morelina Nysti*, *Spatangus Sambiensis*, *S. bigibbus*, and *Scutella germanica*. Mayer says it is of the same age as the glauconitic sand of Egeln or lower oligocene.

The deposit is of marine origin, and the amber has been transported along with it, from some continent into the sea. Zaddach gives details to prove that this glauconitic sand was derived from the lower cretaceous and Silurian formations still represented further north ; that it was brought down by the river into a sea, the tidal current of which deposited it where we now find it. This locality coincides with what was then a bay on the northern shore of the sea which stretched away towards the south-west.

AMBLYGONITE. In addition to the characters already given [E. C. vol. i. col. 142], we may mention that its surface is frequently marked with yellowish and brownish spots ; that the sides of the prism form angles of 106° 10′ and 77° 50′ ; and that it fuses with a reddish yellow phosphorescence into a white enamel. The analysis made by Rammelsberg of a specimen from Arnsdorf gave a somewhat different result from that obtained by Berzelius ; he found it to contain :—

Phosphoric acid	47·15
Alumina	38·43
Lithia	7·03
Soda	3·29
Potash	0·43
Fluorine	3·11

On comparing the two it will be noticed that the alumina and lithia are nearly the same in both ; the phosphoric acid less, and the other ingredients new. This change appears to be due partly to a portion of the phosphoric acid having been replaced by fluorine, and partly to the introduction of fluorides. Consequently this must be regarded as an impure Amblygonite. This is the only mineral known which contains anhydrous phosphate of alumina, and as it occurs associated with garnet, topaz, and tourmaline, in granite, at Chursdorf and Arnsdorf in Saxony, and at Hebron, Maine, U.S., it is the oldest known phosphate of alumina. This fact, together with its highly developed crystalline condition, renders it possible that it may have been derived from similar, but hydrated, phosphates.

AMBRITE, a fossil resin, found in New Zealand, and closely allied to amber. It is of a greyish yellow colour, and breaks with a conchoidal fracture. The specific gravity is 1·054, and the hardness 2. It is nearly insoluble in alcohol, oil of turpentine, caustic alkali, and dilute acids. Its composition, according to R. Maly, is—

Carbon	76·55
Hydrogen	10·38
Oxygen	12·78
Ash	·19

The formula deduced is $C_{32}\ H_{26}\ O_4$.

It is extensively sold in Auckland under the name of cowdie gum, or Australian Dammara resin, which is the name for the resinous product of the Kauri pine (*Dammara australis*). Ambrite, however, is not a recent product, but occurs in large lumps in the tertiary lignites at Drury and Hunna, Auckland Province. This external resemblance between the recent and fossil products is remarkable. Cowdie differs in many respects from Ambrite, but principally in being soluble in alcohol and alkalis.

AMMONIA (H_3N). The physical properties and mode of obtaining this gas are given under AMMONIA, E. C., Arts and Sciences Division ; and we propose here to give some account of its relations to plants and animals. It occurs as a carbonate in the atmosphere, and as a nitrate in rain water, more especially that which falls during a thunder-storm ; it exists in sea-water, in many mineral springs, in nearly every kind of clay, soil, and iron ore ; it enters into the composition of sal-ammoniac and ammonia alum, both of which are common minerals ; and it is contained in the sap of plants, as well as in the fluids and excrements of many animals. Ammonia, either free or combined, is formed by almost all nitrogenised organic substances when they putrefy; and it is also formed by many non-nitrogenous organic compounds when exposed to the prolonged action of air and water.

The real importance of ammonia to animals and plants cannot be comprehended so long as we confine our attention to its presence as free ammonia ; but it becomes much clearer when we look at it from a chemical point of view. On referring to ORGANIC BASES, E. C., A. & S. Div., the general principle regulating the formation of the organic bases containing nitrogen will be seen, and also the way in which these bases have been classified by chemists. Assuming that the reader is acquainted with the remarks made in the article referred to, we would again repeat that chemists are still of opinion that the atoms of nitrogen in all organic compounds of natural formation, are the representatives or residues of as many molecules of ammonia; that these compounds are built up in a particular way from the elementary types, carbonic acid (CO_2), water (H_2O), and ammonia (H_3N). These substances, it will be noticed, are the principal ingredients of the food required by plants. From the former two numerous complex organic products are formed by a constant process of deoxidation, which process appears to be one of the most striking characteristics of plant life. But there are many vegetable substances in which nitrogen forms a constituent, as, for example, the important group of the nitrogen alkaloids, which includes caffeine, asparagine, codeine, morphine, &c. Now, no amount of deoxidation could deprive ammonia of its hydrogen ; so that, if ammonia really is the source of the nitrogen in plants, this process must be otherwise explained. The explanation is, that in nitrogenous compounds the atoms of nitrogen are built into the complex molecule by constant dehydration, *i. e.* by the successive removal of the elements of water. We cannot afford space to give any practical illustration of this here, but these principles seem to show the close connection there is between the elimination of moisture and oxygen from plants and the building up of their products. As dehydration tends to increase the complexity of the nitrogenous compounds, so on the other hand hydration tends to split them up into simpler compounds. Their nitrogen being the residue of ammonia (H_3N) is always ready, under favourable conditions, to reunite itself with the hydrogen from which it has been separated. Hence it is, that when the plant dies and is exposed to moisture, it putrefies and gives off its nitrogen in the form of ammonia; and the same remark will apply to animals.

The ammonia found in blood has been supposed to be the cause of its fluidity ; so that, when the blood is exposed to the air, the volatile ammonia escapes, and consequently the coagulation sets in. This theory was propounded by Dr. Richardson, in 1857, but it has found little favour amongst physiologists. [BLOOD, E. C. S.]

As far as our knowledge extends at present, there is no way known by which nitrogen and hydrogen in the free state can be combined to form ammonia. It appears to be essential that one, at least, of the gases, be in the nascent form. In nature the only important source of ammonia is through the medium of organic substances. Hence Bischof concludes that all natural ammonia has been produced under the influence of organisms. Some of the places where it occurs, such as the clays and iron ores, as mentioned at the beginning of this article, are apparently opposed to this view ; but since such clays and ores were deposited or formed in water which certainly contained decaying organic matter, there is no reason for supposing they did not yield ammonia, and that the ammonia so formed was not absorbed by the clays and ores. A more difficult case to explain is the ammonia of the aqueous vapours from the suffioni in Tuscany. But if, as is probable, this vapour was derived from the sea, it must have contained more or less organic matter, which would account for some of, if not all, the ammonia. If it did not come from the sea, and did not originally contain organic matter, it might still have derived ammonia from the fossiliferous limestone rocks which underlie the mouths of the suffioni.

(Odling, *Lectures on Chemistry*; Watts, *Dictionary of Chemistry*; Bischof, *Chem. & Phys. Geology.*)

AMMONITES [E. C. vol. i. col. 144—149]. The great group of the *Ammonitidæ*, which has been so enthusiastically studied of late years, and which has received such an immense accession to the number of its reputed species, is now believed to embrace upwards of 1600 specific forms, of which the genus *Ammonites* yields nearly one half. There are few, if any, genera so difficult to arrange as *Ammonites* and *Terebratula*. The student of the latter, however, has the advantage of checking his observations on the calcareous covering of the extinct species by an examination of such of the allied generic forms as still exist in modern seas. The student of the *Ammonites* has not the opportunity of studying any living individuals of this genus, nor even of the family to which it belongs. Indeed the great tetrabranchiate order is only represented in the present seas by a few species of *Nautilus*. From the fact of the family being wholly extinct, describers have been almost compelled to derive their distinctive characters from the shell itself, and hence they have neglected, and we might say ignored, the opportunities which the living tetrabranchiates afforded of understanding the relations which the shell characters had to the soft parts. It is mainly owing to this neglect that so many false species have been created. Thus we find the various stages of growth of the same species invested with specific names, a circumstance which plainly shows that the authors of those names were not acquainted with the characters which indicate the age of the shell. The earlier observers were also unacquainted with the position of the animal in the shell. In the univalve shells the dorsal surface is situated next the outer and longer curve of the whorl, and the ventral is normally directed towards the inner curve. In the *Nautilidæ*, and there is reason to believe in the majority of tetrabranchiates, the animal was placed in the opposite position, that is, the back is towards the inner or concave part of the whorl, and the ventral surface towards the outer or convex part. In short, the direction of curvature with respect to the animal is entirely different in the *Ammonites* and other cephalopods from that in the gastropods and other univalve *Mollusca*. In most of the *Ammonitidæ* the shell is curved in the same plane, but in some the shell is turreted; in all these the direction of curvature is such that when the mouth of the shell is facing the observer it is situated on the side of the base of the cone opposite his left hand; while in the gastropod the usual position of the mouth when the shell is in a corresponding position is on the right side. In conchological language, the turreted tetrabranchiates, such as *Turrilites*, is said to have a sinistral shell, while the gastropod has a dextral shell; but these terms scarcely suffice to give the right impression; for, having regard to the structural form of the animals, the sinistral cephalopodous shell corresponds to the dextral gastropodous shells. We say the one corresponds to the other, because in both the spire is on the right side of the animal itself. If the reader bears these points in mind, he will be able at a glance to see what position an *Ammonite* is in. If the mouth is turned towards his right hand, he is looking at the left side of the shell; while he is looking at the right side if it is turned downwards towards his left hand. In the case of most non-cephalopodous univalves the rule is just the reverse.

In col. 148, vol. i. E. C., it was remarked that at some future day the character of the aperture of the shell would be employed as important aids in classification. This prediction was fulfilled in the classification proposed by Suess in 1866, in which he pointed out the relations between such characters and the general position of the animal in the shell. The most striking feature in *Ammonites* is the wide difference in the proportion which the last chamber, or that which contains the animal, bears to all the others. In some, as for example, in *A. subumbilicatus* and its allies, this chamber occupies a whorl and a half; while in others, such as *A. radians*, it scarcely occupies more than half a whorl. Amongst the long chambered species the aperture of the shell has a simple margin, while in the short chambered shells this margin is usually drawn out into processes of greater or less length. On further examination, the shell yields evidence which seems to show that the animals in the short chambered shells were able to draw back neither rapidly nor entirely under cover, while the long chambered species could withdraw completely into the shell.

Each of these two great groups are separable into others, to which Suess assigns a generic rank. The long-chambered group forms two genera, viz., *Arcestes*, which embraces most of the species usually referred to the *globosi* group, such as *A. galeiformis*, *A. subumbilicatus*, *A. Johannis Austriæ*, and others; as well as such high-mouthed forms as *A. Metternichii*, *A. imperatori*, *A. Layeri*, *A. dux*, *A. Dontianus*. The second genus is *Phylloceras*, and comprises the *Heterophylli*, and a few of the cretaceous *Ceratites*. It includes such forms as *A. heterophyllus*, *A. tatricum*, *A. Zignodianum*, *A. Zetes*, *A. Velledæ*, *A. Mimatense*, and others. The range of these genera in geological time is widely different, for *Phylloceras* ranges through most of the secondary formation, while *Arcestes* is confined to the Triassic beds.

The short-chambered species are also formed into several genera. Amongst the *Fimbriati*, the dorsal side of the mouth was produced forward in a long projection. A similar projection occurred in *Baculites*, *Crioceras*, *Ancyloceras*, and other genera; but there is no relation between this part in the two groups, since it is situated on the dorsal side in the *Fimbriati*, and on the ventral side in the *Baculites*, &c. The *Fimbriati* are further distinguishable by their involute whorls, the ornamentation of the shell, and the complicated antisiphonal lobe (by which term is meant what was formerly called the ventral lobe). This group Suess calls by the generic name *Lytoceras*. It first appears in the Lias.

In most of the other groups there was one or two processes projecting from the lateral or ventral edge of the mouth, which were secreted by, and gave support to, the muscles which kept the animal in its shell. These processes consist sometimes of a spoon or plate-shaped continuation of the margin of the shell, sometimes of a long or short narrow projection, and sometimes of both these parts. Suess calls the first *Myothek*, and the latter *Myolab*. In the *Amalthei*, *Falciferi*, *Cristati*, and similar groups, the ventral process was small; and, so far as can be ascertained, the animal appears to have been able to retreat entirely within the shell. The *Aones* and *Rhotomagenses* groups had a short, round, and broad ventral process; while the *Ornanti* proper, the *Flexuosi*, the *Canaliculati* and the *Tricarinata* possessed both Myothek and Myolab. The *Planulati* and *Coronati* also possessed these during a portion at least of their life. In these last mentioned forms the body was only partially covered.

The Ammonites are, as has already been said, restricted to the secondary formations; and of all the molluscan group, no other is of such general occurrence, and no other presents species which are for the most part so restricted in their range. Hence the palæontologists have lately employed the succession of Ammonite species as a means of marking off the secondary beds into zones, each zone being named after an Ammonite, or, if an Ammonite is not convenient, from some other species of *Mollusca*. These zones, or representatives of epochs in time, do not include the whole of the period which elapsed between the first and last appearance of the species used to mark such zones, but they indicate the time during which a set of beds having certain definite distinctions were deposited, which beds contain the Ammonite in question in considerable abundance, associated with a particular fauna. If the Ammonite occurs without the fauna, it is not regarded as a proof of the age of the beds belonging to the zone named after it. These zones have been of considerable service to the geologist, but they require to be accepted with great caution, since it would seem that in some instances they are not fully to be relied on as indications of relative time. As an example of these zones, we append a list of those recognised in this country in the liassic and oolitic formations, the first mentioned being the latest in time :—

NAME OF ZONE.	GEOLOGICAL BED OR FORMATION.
A. Parkinsoni	Upper Trigonia Grit. Gryphite Grit. Lower Trigonia Grit.
A. Humphresianus	Upper Freestone.
A. Murchisonæ	Oolite Marl. Lower Freestone. Pea Grit.
A. Jurensis	Upper Lias.
A. communis	
A. spinatus	Middle Lias.
A. margaritatus	
A. Davœi & Henleyi	
A. raricostatus	Lower Lias.
A. oxynotus	
A. obtusus	Belemnite Beds.
A. Turneri	
A. Bucklandi	Arietien Beds.
A. angulatus	Hettangien Beds.
A. planorbis	

The distribution, geographically, of the genus *Ammonites* may be regarded as world-wide, since species have been recorded from

North and South America, from almost every part of Europe, from South Africa, from Asia, more especially southern India, and from New Zealand. The materials are now so abundant that some clue might be gained as to the law of the distribution of *Ammonites*. Such a task would take us far beyond our limits; but it is remarkable that some species appear to have extraordinarily wide geographical ranges. Thus, of the 93 Indian species found in S. India, 19 are also met with in European strata, and one, viz., *A. Gardeni*, is found in India, Africa, and Europe. All the species are from cretaceous rocks. The following are their names:—

A. Ootacadensis, Stol.
A. subtricarinatus, D'Orb.
A. inflatus, Law.
A. caudallianus, Pictet.
A. Gardeni, Baily.
A. Rothomagensis, Defrance.
A. navicularis, Mant.
A. dispar, D'Orb.
A. Mantelli, Law.
A. Guadaloupæ, Römer.
A. Orbignyanus, Geinitz.
A. Largilliertianus, D'Orb.
A. subalpinus, D'Orb.
A. peramplus, Mant.
A. Beudanti, Brongn.
A. Trinotheanus, Major.
A. latidorsatus, Mich.
A. Velledæ, Mich.
A. Rouyanus, D'Orb.

In order to indicate the relative geological positions of many of the principal species of *Ammonites*, we will give first an outline of Seebach's classification of the Oolitic beds of Hanover, and then a list of the species occurring in the British Isles. In both cases the beds are enumerated in their inverse order, the oldest and lowest being named first.

According to Seebach, the Lias consists of:—

1. Psilonotus beds, with *A. Johnstoni.*
2. Angulatus beds, with *A. angulatus.*
3. Arietes beds, with *A. Bucklandi*, and *A. Conybeari.*
4. Planicosta beds, with *A. planicosta*, and *A. ziphius.*
5. Brevispina beds, with *A. brevispina*, *A. binotatus*, and *A. Jamesoni.*
6. Capricornus beds, with *A. capricornus*, and *A. curvicornus.*
7. Amaltheus beds, with *A. margaritatus*, and *A. spinatus.*
8. Posidoniæ beds, with *A. Lythensis*, *A. borealis*, and *A. communis.*
9. Jurensis beds, with *A. dispensus*, *A. striatulus*, *A. Germanii*, *A. insignis*, *A. Jurensis.*

The Dogger group is divided into:—

1. Opalinus beds, with *A. radiosus*, and *A. opalinus.*
2. *Inoceramus polyplocus* bed, with *A. Murchisonæ*, and *A. cycloides.*
3. Coronatus beds, with *A. Breckinridgei*, *A. pinguis*, *A. Gervillii*, *A. Sauzei*, and *A. Humphresianus.*
4. Parkinsoni beds, with *A. Parkinsoni.*
5. *Ostrea Knorrii* beds, with *A. orbis.*
6. No Ammonite is mentioned.
7. Ferruginous limestone, with *A. posterus.*

The Upper Oolite is divided into:—

1. Macrocephali beds, with *A. macrocephalus*, *A. Gowerianus*, *A. funatus*, and *A. calvus.*
2. Ornatus clay, with *A. Lamberti*, *A. cordatus*, *A. ornatus*, and *A. Jason.*
3. Hersum beds, with *A. cordatus* in lowest part; *A. perarmatus*, and *A. mendax.*
4. Coral beds, with *Isastræa helianthoides.*
5. Coral oolite, with *Cidaris florigemma*, &c.
6. *Nerinæa Visurgis* beds, with *N. Visurgis*, &c.
7. Pterocerus beds, with *Pterocerus Oceani*, &c.
8. *Exogyra virgula* beds, with *E. virgula*, &c.

No *Ammonites* specially characterise beds 4—8.

9. *A. gigas* bed.

The list of British *Ammonites* is drawn up from the 'Catalogue of the Fossils in the Museum of Practical Geology,' by Professor Huxley and R. Etheridge.

Lower Lias:

A. obtusus.
A. Conybeari.
A. Bucklandi.
A. stellaris.
A. Dudressieri.
A. Henleyii.
A. Charmani.
A. Birchii.
A. Brookii.
A. angulatus.
A. Turneri.
A. oxynotus.
A. armatus.
A. Carusensis.
A. ziphius.
A. planicostatus.
A. heterogenus.
A. maculatus.
A. figulinus.
A. hallecius.
A. Bechei.
A. forficatus.
A. obliquatus.
A. tortilis.
A. semicostatus.
A. raricostatus.
A. Sauzianus.
A. catenatus.
A. aureus.
A. nodulosus.
A. planorbis.
A. Guibalianus.
A. lævigatus.
A. Robinsoni.
A. accipitris.
A. Dennyi.
A. trivialis.

Middle Lias:

A. Engelhardtii.
A. fimbriatus.
A. margaritatus.
A. armatus.
A. spinatus.
A. Maugenistii.
A. Boblayei.
A. capricornis.
A. Davæi.
A. semicostatus.
A. complanatus.
A. Loscombii.
A. hybridus.
A. vittatus.

Upper Lias:

A. serpentinus.
A. Mulgravius.
A. Thouarsensis.
A. Normanianus.
A. independens.
A. variabilis.
A. Moorei.
A. radians.
A. falcifer.
A. striatulus.
A. Lythensis.
A. solaris.
A. candidus.
A. bifrons.
A. Aalensis.
A. opalinus.
A. elegans.
A. annulatus.
A. communis.
A. Bollensis.
A. crassus.
A. Desplacii.
A. fibulatus.
A. Holandrei.
A. Raquinianus.
A. insignis.
A. Grenouillouxii.
A. cornucopia (?).
A. heterophyllus.

Inferior Oolite:

A. Dorsettensis.
A. Parkinsoni.
A. Jurensis.
A. Humphresianus.
A. Blagdeni.
A. Brongniarti.
A. Murchisonæ.
A. Tessonianus.
A. Sowerbyi.
A. Eudesianus.
A. Gervillii.
A. Brocchii.
A. Sauzei.
A. polymorphus.
A. Martinsii.
A. Linneanus.
A. Garantianus.
A. insignis.
A. Edouardianus.
A. zigzag.
A. Caumontii.
A. Defrancii.
A. concavus.
A. subradiatus.
A. Truellii.
A. ooliticus.

Fuller's Earth:
A. Gervillii.

Stonesfield Slate:
A. hecticus.

Great Oolite:
A. subcontractus.
A. macrocephalus.

Forest Marble:
A. Bakeriæ.

Cornbrash:

A. discus.
A. macrocephalus.
A. Bakeriæ.

Kellaway's Rock:

A. tumidus.
A. cordatus.
A. lenticularis.
A. modiolaris.
A. sublævis.
A. Kœnigi.

Kellaway's rock, *continued.*

A. Eudoxus.
A. Brightii.
A. Gowerianus.
A. Callovicensis.
A. macrocephalus.
A. Gulielmi.
A. perarmatus.

Oxford Clay :

A. Reginaldi.
A. Kœnigi.
A. Lalandeanus.
A. athletus.
A. Cymodoce.
A. excavatus.
A. lenticularis.
A. sublævis.
A. modiolaris.
A. macrocephalus.
A. Eumelus.
A. perarmatus.
A. spinosus.
A. cordatus.
A. omphaloides.
A. Gowerianus.
A. Lamberti.
A. vertebralis.
A. Arduennensis.
A. Mariæ.
A. hecticus.
A. Eugenii.
A. biplex.
A. Bakeriæ.
A. Duncani.
A. Baugieri.
A. crenatus.
A. fluctuosus.
A. Achilles.
A. Comptoni.
A. Stutchburyi.
A. Jason.
A. Gulielmi.
A. Lonsdalii.
A. Brightii.
A. Sedgwickii.

Coral Rag :

A. perarmatus.
A. Achilles.
A. cordatus.
A. Arduennensis.
A. Lamberti.
A. biplex.
A. sublævis.
A. eupalus.
A. eudoxus.
A. plicomphalus.
A. modiolaris.
A. triplex.

Kimmeridge Clay :

A. triplex.
A. Lamberti.
A. plicatilis (?)
A. Bakeriæ.

Portland Stone :

A. rotundus.
A. giganteus.
A. biplex.
A. triplex.

Lower Greensand :

A. Deshayesii.
A. interruptus.
A. mammillaris.
A. Cornuelianus.
A. Hambrovii.
A. Martinii.
A. reticostatus.
A. Nutfieldiensis.

Gault :

A. splendens.
A. dentatus.
A. interruptus.
A. lautus.
A. tuberculatus.
A. duplicatus.
A. mutabilis.
A. concinnus.
A. venustus.
A. evalidus.
A. fissicostatus.
A. cavaticus.
A. rotula.
A. Speetonensis.
A. hystrix.
A. mammillaris.
A. Bouchardianus.
A. cristatus.
A. Goodhallii.
A. varicostatus.
A. Coupei.
A. rostratus.
A. inflatus.
A. auritus.
A. denarius.
A. varians.
A. circularis.
A. Jeannottii.
A. symmetricus.
A. proboscideus.
A. Selliguinus.
A. elegans.
A. minutus.
A. trifurcatus.
A. Bennetianus.
A. velledæ.

Upper Greensand :

A. auritus.
A. varicosus.
A. rostratus.
A. varians.
A. interruptus.
A. Goodhallii.
A. mammillaris.
A. Beudantii.

Chalk Marl :

A. navicularis.
A. Rothomagensis.
A. Mantelli.
A. varians.
A. Coupei.
A. rostratus.
A. Austeni.
A. rusticus.

Lower Chalk :

A. Rothomagensis.
A. navicularis.
A. varians.

Upper Chalk :

A. Griffithii.
A. Lewisiensis.

AMŒBA, the typical form of a group of lowly organized animals constituting the order *Lobosa* in the sub-kingdom *Protozoa.* Apparently it consists of a gelatinous transparent structureless substance, for which Dujardin proposed the term *sarcode*, or rudimentary flesh. In size it varies between $\frac{1}{10}$th and $\frac{1}{2800}$th of an inch in diameter. It lives in rivers and ponds, and creeps about by constantly altering the form of its body (which can scarcely be said to have any definite shape), and from which are thrown out short broad processes (*fig.* 1). In *Amœba* and its allies these processes, or *pseudopodia*, are short and lobated, a character readily distinguishing them from other Rhizopods, in which the *pseudopodia* are long and slender. The *Amœba* is a restless creature, and is seldom, if ever, found inactive. Portions of the body are bulged out on one side, and then retracted, the effect of which is to draw the body in the direction of the extensions. Under the microscope the creature appears to advance by a kind of rolling action, but this is an optical illusion ; in reality it is a creeping motion. This is an important observation, for on the supposition that the creature rolls over, the *pseudopodia* would be extended from every part of the body indifferently ; whereas, if it is a mode of reptation, the *pseudopodia* will be extended from one surface only. On this latter hypothesis there is a ventral surface and a dorsal surface in these animals. This view is strengthened by the fact that in some of the forms of *Amœba*, or species as they are termed, the *nucleus* and *contractile vesicles* remain unaltered in position with respect to the other parts of the body.

The *Amœba* feeds upon almost any minute object that its processes come in contact with : *Diatomaceæ, Desmidiæ,* fragments of *Algæ, Infusoriæ, Rotiferæ, Entomostracæ ;* inorganic particles, such as sand ; all are alike taken into its interior. There appears to be no selection. There is no oral aperture for the introduction of food, which seems to be forced into the substance of the animal's body much as a stone might be thrust into a lump of clay. If the object ingested is large, it is gradually reduced to minute granules, which are diffused through the interior of the animal, imparting to it a colour corresponding to that of the granules. Such of the food as the creature cannot dissolve is gradually expelled in much the same way as it was taken in.

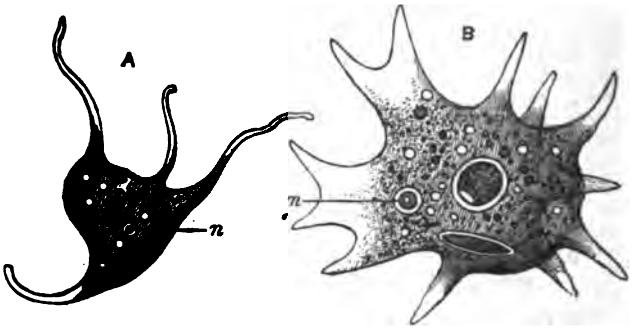


Fig. 1.—A, A young individual of *Amœba radiosa ; n*, nucleus. B, A variety of *A. radiosa ; n*, nucleus. (After Carpenter.)

However lowly organized the *Amœba* may be, it is not without some differentiation of parts. The periphery of its body has a certain amount of consistency, while the inner portion is fluid, or in other words, a gelatinous *ectosarc* surrounds and gradually passes into a liquid *endosarc*, which increases in fluidity as the centre is approached. The difference between the two is strongly marked in a well-fed *Amœba*, since the coloured granular portion of the food is diffused through the *endosarc*, and not through the *ectosarc*. Indeed, in some forms of *Amœba* (as *A. bilimbosa*), the superficial portion of the *ectosarc* appears to have a membranous consistency ; but this envelope is not permanently continuous, as it is broken every time a *pseudopodium* is extended. It must not, however, be supposed that any definite boundary line exists between the *endosarc* and the *ectosarc ;* the two parts gradually merge into each other. The food undergoes a kind of circulation before it is completely digested. This circulatory movement somewhat resembles the peristaltic motions of the stomach in higher animals. It is promoted partly by the constant mutation of the form of the gelatinous *ectosarc*, and partly by means of the contractile vesicles. In the interior of most *Amœbæ* there may frequently be noticed a central solid particle (*fig.* 1, *n*) surrounded by a clear, flattened vesicle, and adherent to the inner portion of the *ectosarc*. This is termed the *nucleus*. There are also one or more clear spaces, or *contractile vesicles*; but these latter are almost always found in the *ectosarc* only, and generally at its outer surface. These vesicles slowly contract and enlarge; the period intervening between the contractions varies from half a minute to three or even five minutes. In expanding they become filled with a colourless fluid, which is discharged into the interior of the animal's body on contracting. Such is the simple organization of the *Amœba*; but notwithstanding its simplicity, naturalists have not yet obtained a clear conception of the way in which digestion, reproduction, and other processes are carried out.

A thorough examination into the chemical composition of the *Amœba* would throw great light on many of these points, and also on many questions relating to the economy of animals higher in organization. The bodies of all the *Protozoa* are believed to be chemically identical, and to be composed of the substance, or *protoplasm* as it is termed, from which all animal tissues are evolved by a process of gradual differentiation. In the *Amœba* we have the traces only of a differentiation. In it the sarcode is composed of an albuminoid base, having dispersed through it a number of oil particles. It is soluble in alkalies, is rendered transparent by acetic acid, and tinged brown by iodine. The ectosarc and endosarc behave somewhat differently when treated with reagents. If *A. radiosa* be treated with a dilute alkaline solution, the endosarc contracts upon itself, while the ectosarc remains unaltered and is seen to consist of a surrounding envelope, from the inner surface of which, radiating extensions or septa project towards the centre of the animal's body. The nucleus is also soluble in alkalies, but it is rendered darker and more distinct by dilute acetic acid, in consequence of the precipitation of granular matter in the clear space which surrounds the central solid particle of the nucleus. If the acid is strengthened, the nucleus is dissolved. In *A. bilimbosa* starch granules have been detected by Auerbach.

There are several modifications of the ordinary Amœban type. One remarkable form, *Podostoma*, occurs abundantly in an aquarium at Berlin, and very much resembles *Amœba* when at rest, but differs from it in having a long whip-like filament at the end of its broad, short pseudopodiæ, with which the surrounding water is lashed. When it comes in contact with any object the filament is coiled round it, and the process of ingestion proceeds as in *Amœba*. There are others which possess tests enveloping them wholly or partially. Thus in *Pseudochlamys* there is a carapace on the back (shaped somewhat like the shell of a limpet), which possesses sufficient pliability to change its form with the motions of the body. *P. patella* has from 6 to 10 contractile vesicles and 1 nucleus.

There are two principal types of testaceous *Amœbinæ*, viz., *Arcella* and *Difflugia* (*fig.* 2, A and B). In *Arcella*, the test, as the firm outer coating is called, is membranous in consistency, and hemispherical in form; sometimes it is flattened, and sometimes it is vasiform. It is perforated with but one aperture, through which the pseudopodia are protruded. The animal creeps with the mouth of the shell downwards, so that in this case there can be little doubt there is a differentiation of the ventral from the dorsal surface. There are several contractile vesicles, which are situated near the outer edge of the hemisphere. The test is incapable of growth, so that from time to time the animal is compelled to withdraw from it. This it does by projecting a portion of its sarcode body from the aperture of the test it has grown too bulky for. A new test forms on the portion thus exposed; at first it is thin, transparent, and colourless, but it gradually thickens, at the same time acquiring opacity, and a light yellowish-brown colour. The old and new tests are developed with their apertures opposite each other, and the sarcode body passes alternately from one to the other until the new test has acquired sufficient consistency. The final evacuation from the old test is generally attended by so much violence that it splits. In *Difflugia* the test is usually spherical or ovoidal, the single aperture being at one end; it is thin and membranous, and wanting in firmness, when freed from the particles of sand and shell which are always found adhering to its external surface. The *Pamphagus* of Bailey is regarded by some as belonging to the *Amœbinæ*.

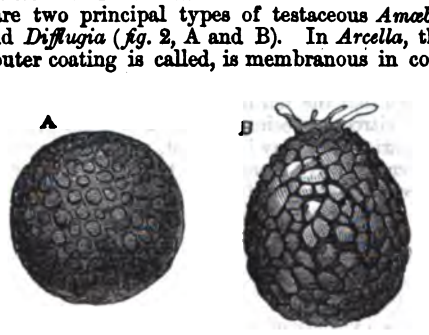


Fig. 2.—A, *Arcella vulgaris*; B, *Difflugia globulosa*. (After Carpenter.)

Our knowledge of the distribution of the group of creatures noticed in this article is too insufficient to enable us to draw any general conclusion. There is, however, this remarkable point, that all the forms hitherto discovered have been inhabitants of fresh water. Prof. Bailey ('Am. Jl. of Sci.' 1856) reports the occurrence of *Difflugia marina* at a depth of 2700 fathoms in the Atlantic. It is doubtful if the creature found under these conditions has been correctly assigned to this genus, all the other members of which live in fresh water. *Pamphagus* is found in the sea, but this form is probably nearly allied to Actinophrys. [See ACTINOPHRYS, E. C. S.] *Amœba* has been found in Europe and India, but is probably far more widely distributed. *Difflugia* and *Arcella* occur in Europe, Asia, and America.

(Carpenter, *Introduction to the Study of the Foraminifera*; Greene, *Manual of the Protozoa*.)

AMPELIS. [BOMBYCILLA, E. C. S.]

AMYGDALOID [E. C. vol. i. col. 188]. In the place referred to it is said to be a variety of trap rock. An amygdaloid is more properly speaking a rock which presents a peculiar structure, which structure may be found in rocks differing widely in their composition and general character. The name, therefore, is not that of any one species of rock, but that of varieties of several species of rock which agree only in having an amygdaloidal character, while they differ in others which are far more essential.

The structure is due to cavities in the rock having been filled up with certain minerals. The cavities vary greatly in size and the degree to which they have been filled up. Generally the small ones are entirely occupied, and the large ones only partially so; but instances occur in which the opposite state of things is met with, so that the large cavities are filled, but not the small ones. The rocks in which the cavities are filled are said to be amygdaloidal, and those in which the cavities have not been entirely obliterated are called drusy. These two states merge into one another, so that cases occur in which it is difficult to decide which term to apply.

The cavities appear in most cases to have been formed by gas-bubbles rising through the rock when in a semi-plastic condition, and they are most commonly found in such as have flowed as lavas from ancient volcanoes. Similar cavities are formed in the lavas of the present period, but they are never filled up. Their shape varies from globular to oval and linear, and their inner surface is generally smooth. The usual minerals are those which characterise mineral veins, such as quartz, amethyst, chalcedony, calcite, dolomite, zeolites, barytine or heavy spar, and delessite. They have been introduced by infiltrating water, and many of them are hydrated. The amygdules, or the substances filling the cavities, are sometimes formed of one mineral, and sometimes of several minerals, or different varieties of the same mineral arranged in concentrically parallel bands. Sometimes the layers are arranged horizontally one above another, as in the figure under AGATE, E. C. It is remarkable that the agate amygdules with horizontal layers predominate in some, while those with concentric layers prevail in others. The hollow amygdules occur in rocks poor in silica, rarely in those which are rich that substance.

In the great majority of instances the amygdules are formed of minerals introduced into previously existing cavities by the action of water, but sometimes they appear to have been formed by the conversion of augite crystals into calcite, and sometimes by the alteration of the pebbles in a conglomerate. As amygdules are formed in various rocks, such as basalt, dolerite, melaphyre, diabase, augite-porphyry, &c., it has been found convenient to distinguish the different amygdaloids by such names as basalt-amygdaloid [BASALT, E. C.], melaphyr-amygdaloid, greenstone-amygdaloid, and so on.

(Zirkel, *Lehrbuch der Petrographie*, Bd. i. 1866.)

AMYLOID SUBSTANCE. [STARCH, E. C. S.]

ANALCIME ($Na_2O. SiO_2 + Al_2O_3. 3 SiO_2 + H_2 O$) is one of the zeolites, which crystallises in the regular or cubic system, and yet possesses physical properties which as a rule do not belong to the minerals of that system. The general characters have already been described under ANALCIME, E. C., where, however, *Sarcolite* is said to be a synonym. It is really a silicate of alumina and lime, and forms one of the varieties of *Scapolite*. Analcime usually occurs in 24-sided crystals similar to those of leucite, whence they are sometimes called leucitohedrons; it is also sometimes met with in cubes with the eight solid angles replaced by the faces of an octahedron. The purest crystals are colourless and transparent, but sometimes white, inclining to grey or flesh colour. It is only when they become reddish that they are opaque, and of more than the usual size. There are also lamellar, globular, and fibrous varieties. The principal peculiarity about analcime is its power of polarizing light. Crystallographers assert that all crystals not belonging to the regular system are doubly refracting, and that the regular crystals refract light singly. Moreover, it has been found that when a doubly refracting substance is looked at by means of polarized light it developes colour. Hence it is frequently assumed that when a crystal appears coloured by polarized light it belongs to a doubly refracting substance. Analcime, as we have seen, belongs to the regular system, and yet it developes colour under polarized light. This anomaly is usually explained by means of Biot's theory of lamellar polarization, and by considering analcime to be somewhat analogous to a bundle of glass plates, which is capable of polarizing light by refraction, although this property is not possessed by the homogeneous substance of the plates when separated. This supposition is not entirely unwarranted, for on examining crystals of analcime a series of equidistant bands of different tints may be detected, which with the peculiar lamellar fracture seem to indicate that they have been built up of a series of superposed plates. According to De la Fosse, the crystallization has occurred during a series of regular periods of rest and action. The crystals of other minerals present a similar stratified structure, but in them the building up has been by an irregular, not a regular process. Amongst the few minerals possessing this regular compound structure are nitre, arragonite, topaz, and apophyllite, while boracite, rock-salt, and ammonia alum give rise to the phenomena of lamellar polarization. Leucite and the diamond also appear to possess similar properties.

Analcime occurs in numerous localities in America, as well as in Europe, principally in clefts and geodes in granite, trap-rocks, lava, diorite, and dolerite. Among the American localities may be mentioned the Lake Superior region, especially the Copper Falls and North Western Mine, where it occurs as large transparent trapezohedrons (or leucitohedrons, as this form is sometimes termed), in a greenish magnesian silicate. They are always associated with a peculiar kind of orthoclase, and under such circumstances as to indicate that both must have been formed at the same time.

(Whitney, *Am. Jl. Sci.* [2] xxvii. 8; De la Fosse, *Nouveau Cours de Minéralogie*, iii. 305; Watts, *Dict. of Chemistry*.)

ANDALUSITE. It is an anhydrous silicate of alumina ($SiO_2. Al_2O_3$) in which the silica and alumina are combined in equal atomic proportions. It may, therefore, be conveniently looked upon as the typical form amongst the group of crystallised minerals to which it belongs, viz., the anhydrous silicates of alumina. This group comprises about a dozen minerals, supposed by some mineralogists to belong to as many different species; but it is probable that nearly one-half of them are simply varieties. The characteristics of andalusite and its relation to other species will be best shown by examining these minerals *seriatim*, beginning with those containing the largest proportion of silica.

Nacrite ($3 SiO_2. Al_2O_3$).—No analysis has been given of the anhydrous form of this mineral. Thomson's analysis [NACRITE, E. C.] contains 1 per cent. of water, together with 4·4 per cent. of the protoxide of iron. The presence of these two constituents will probably account for its possessing an argillaceous odour when breathed upon. Its specific gravity is less than that of any of the following minerals, which is in harmony with its composition, since silica is lighter than alumina, the former being about 2·6, the latter about 4.

Bamlite ($9 SiO_2. 4 Al_2O_3$).—In appearance, structure, crystalline form, hardness (6—7), and colour, it much resembles kyanite. But it differs from it in chemical composition (containing a larger proportion of silica), in specific gravity, and in its lustre, which last is silky, as in the case of nacrite. According to Watts's 'Dict. of Chem.,' art. *Kyanite*, it has nearly the same chemical composition as kyanite; but there seems to be a considerable difference, if the analyses given under BAMLITE, E. C., and by Erdmann, as follows, are to be depended on:—

Silica	56·90	
Alumina	40·73	=42·81
Peroxide of iron	1·04	
Lime	1·04	
Fluorine	tr.	

Bamlite contains nearly 57 per cent. of silica, whereas kyanite contains about 37 per cent. only. The oxygen quotient, also, is widely different; that of bamlite is ·666 in the purest specimens, while that of kyanite is 1·500. Kobell regards it as a mixture of kyanite and quartz, and De la Fosse makes it a variety of sillimanite. A fresh examination of this mineral is much wanted.

Bucholzite is usually regarded as a variety of sillimanite, as stated in the E. C. [BUCHOLZITE], but neither of the analyses there given correspond with the chemical formula of sillimanite. The original analysis by Brandes (the first given below) gives the formula $2 SiO_2. Al_2O_3$, as also does Thomson's analysis in the Cyclopædia, while that by Erdmann seems to resemble sillimanite in composition. The physical properties assigned to it by Bristow ('Gloss. of Min.,' art. Bucholzite) are undistinguishable from those assigned to sillimanite, and the analyses by Silliman given under (2) and (3) correspond with the formula $SiO_2. Al_2O_3$.

	(1.)	(2.)	(3.)
Silica	46·0	36·16	36·31
Alumina . . .	50·0	63·52	62·42
Peroxide of iron . .	2·5	—	—
Potash . . .	1·5	—	—
Magnesia . . .	—	—	·70

Xenolite is another mineral, which, according to Des Cloizeaux, De la Fosse, and other mineralogists, is a variety of sillimanite. The specific gravity assigned to it by Bristow, viz., 3·58, is higher than that assigned to sillimanite, and rather resembles kyanite.

Andalusite ($Si O_2. Al_2O_3$). The above formula has been adopted as best agreeing with the numerous analyses that have been made, and more especially the recent ones. Bischof gives it the oxygen quotient of 1·333, which corresponds to the formula $9 SiO_2. 8 Al_2O_3$. The analyses (1) by Pfingsten of a specimen from Bräunsdorf, near Freiburg, indicates a tolerably pure andalusite; the others (3) from Katharinenberg, and (2) from Robschütz, are less pure. The green andalusite from Brazil, analysed by Damour (4), also appears to be nearly pure:—

	(1.)	(2.)	(3.)	(4.)
Silica . . .	37·57	36·84	35·74	37·03
Alumina . .	59·88	55·82	56·98	61·45
Peroxide of iron .	1·33	3·22	5·71	1·17
Lime . . .	·61	1·09	·15	—
Magnesia . .	·17	1·14	·20	—
	99·56	98·11	98·78	99·65
Sp. gr. . .	3·07	3·11	3·12	

In addition to the characters given in E. C. [ANDALUSITE], we may notice that the hardness of the hyaline variety is 7·5; and that the vitreous specimens have a specific gravity of 3·16. The colour varies, and may be absent, pale rose, peach, flesh-red, reddish-brown, or olive-green. In the Brazilian hyaline specimens, trichroism is frequently met with, a different colour being presented in the direction of each axis, viz., hyacinth-red, yellowish-green, olive-green. It possesses a strong negative double refraction. The usual colour of andalusite is violet-red or pearl-grey, and specimens are frequently covered with or penetrated by plates of mica and kyanite.

Chiastolite is a variety of andalusite in which foreign matter has been so incorporated with the crystals as to indicate their symmetrical internal structure. This matter is apparently derived from the black schist or other dark matrix in which chiastolite always occurs. Frequently it is of a carbonaceous nature; and hence it is, on exposing the crystal to heat, the colour vanishes, leaving the crystals as transparent and pure as andalusite. Sometimes it consists of portions of the schist itself. The black matter assumes various forms. Sometimes it resembles the Greek χ in form, whence its name: more frequently the centre of the crystal is occupied by a black rhomb, the sides of which are parallel with those of the crystal; while the four angles of the rhomb are connected by four black lines with the four angles of the crystal. In other cases the four corners of the crystal are occupied by four additional, but similar, rhombs; and in still other cases there are a number of dark striæ in the clear portion, which run parallel to the inner sides of the rhombs occupying the angles. In a few instances the prism may be almost entirely black, the only colourless part being a narrow external rim. Chiastolite is widely distributed. The analysis by Landgrabe in E. C. [Macle] is probably erroneous. Most of its properties and its chemical composition are essentially the same as those of andalusite. Its hardness is generally rather less; and in some specimens as low as 5·5.

Sillimanite has a general resemblance to andalusite in chemical composition and physical properties. Its crystalline form is nearly the same, but differently modified; its optical properties are slightly different; but its specific gravity is somewhat greater, or 3·24, and its hardness about 7·25 (not from 8 to 8·5, as in E. C. [Sillimanite]). The analysis by Bowen, given in the same place, does not agree with the analyses more recently made by Silliman and Damour. *Worthite, Monrolite, Fibrolite,* and *Bucholzite* are probably varieties of sillimanite.

Kyanite has the same composition as andalusite, but a different crystalline form. It differs from it in many of its physical properties. Thus, as regards colour, andalusite presents various shades of reddish, which merge gradually into green; while in kyanite the transition shades appear to be of a blue and yellow tinge. Chiastolite developes positive electricity when rubbed with sealing-wax: whereas kyanite developes positive electricity in certain crystals or on certain faces, and negative electricity on other crystals or on other faces. It was from this double electrical property that Hauy proposed to call it *disthene*. Some of the lamellæ of kyanite exhibit two colours at once, viz., a blue band between two white edges: sometimes they give shades of yellowish or blackish grey, the latter colour being probably due to graphite. These phenomena are analogous to those presented by chiastolite. After its crystalline form, the most striking difference between andalusite and kyanite is in specific gravity, which in the latter is about 3·559; that of white kyanite (*Rhætizite*) is 3·67; and that of the blue transparent variety from the Tyrol is 3·661.

Judging from the facts here collected, it might be concluded that the physical properties have a more intimate connection with the crystalline form, than with the chemical composition. For it may be noticed that all the minerals resemble either andalusite or kyanite; that where there is a slight difference in the mode of crystalline development there is a slight variation in the physical characters, but corresponding changes do not appear to accompany differences in chemical composition. For instance, *Bamlite* and *Kyanite* are very similar physically, but widely different chemically; while, on the other hand, andalusite and kyanite are chemically identical, but physically they present a marked contrast. They crystallize in two distinct systems, and round one or other of them all the anhydrous silicates of alumina may be grouped.

Our knowledge respecting these minerals is not sufficiently precise to enable us to make any general or comprehensive observations with confidence; but there seems to be, in the majority of cases, a close relationship between the chemical composition and the specific gravity. Thus, assuming the specific gravity of the silica to be that of quartz, or 2·6, and the specific gravity of the alumina to be that of corundum, or 4, there is a near agreement between the calculated and actual densities. This is shown in the following table:—

		Specific Gravity.	
		Calculated.	Actual.
Nacrite,	3 $SiO_2 . Al_2O_3$	2·9	2·79
Bamlite,	9 $SiO_2 . 4\,Al_2O_3$	2·98	3·0
Bucholzite	$SiO_2 . Al_2O_3$	3·3	3·24
Andalusite			3·16
Sillimanite			3·24
Kyanite			3·67
Xenolite,	$SiO_2 . 2\,Al_2O_3$	3·5	3·5

The principal exception is kyanite, which is exceptionally heavy; but this is associated with so great a modification in its character generally, as to lead one to conjecture that one or other of its constituents is allotropically different from ordinary alumina and quartz.

These minerals occur in rocks having the same composition as themselves. Their lithological distribution is as follows:—

Bamlite occurs in gneiss; nacrite in mica schist and granite: andalusite is most frequent in micaceous schist and gneiss, but also occurs in mica schist, granite, and saccharoidal limestone: chiastolite is most frequent in clay-slate, less frequent in micaceous schist; but is also found in fossiliferous mica schist, dark metamorphic limestones, and greyish dolomite: kyanite is found chiefly in gneiss and mica schist; also in leptynite (a gneissic rock), pegmatite (a granitic rock), eklogite, granulite, saccharoidal limestone, dolomite, and magnesian clays; sillimanite in gneiss; fibrolite in granite. The conclusion indicated is that these minerals occur in the more highly crystalline rocks, which originally consisted wholly or partially of silicate of alumina. (Bristow, *Gloss. of Miner.*; Watts, *Dict. of Chem.*; De la Fosse, *Nouveau Cours de Mineralogie*; Bischof, *Phys. and Chem. Geology*; and Cotta, *Rocks Classified and Described*, translated by Lawrence.)

ANIMAL DEXTRINE. [Starch, E. C. S.]

ANIMAL KINGDOM [E. C. vol. i. cols. 196—205]. The same difficulty exists now as prevailed many years ago, of expressing the essential difference between an animal and a plant in a short definition. When we confine our attention to the least specialized forms of each kingdom, the two kingdoms almost seem to merge one into the other. Thus amongst the Protozoans, or least specialized of animals, there are forms, such as *Amœba*, which are undistinguishable by the eye from certain amœbiform spores yielded by some species of aquatic plants. So simple are these denizens on the confines of the two kingdoms in their organization, that it seems almost impossible to fix upon any positive character whereby to discriminate between them. Aristotle's definition that an animal has a mouth while a plant has not, is so far true that no instance is on record in which an organism admitted to be a plant has shown any signs of possessing an aperture, temporary or permanent, through which nutriment in a solid form is introduced. But there are whole classes of animals which possess no mouth. The great majority of these are parasitic upon or within animals, and derive their nourishment from the animal fluids imbibed by them. So far they agree with many of the parasitic plants. But these groups may, we believe, be readily distinguished, inasmuch as the animals invariably have a ventral and dorsal surface, a feature not to be seen in the plants. But, as has already been pointed out in E. C., the real difference between the two kingdoms is obtained by the consideration of the opposite relations which plants and animals bear to one another, and the relative shares which they perform in the general scheme of nature. This has been partially done in cols. 199, 200; but we propose to develope the ideas there expressed a little more fully. Plants are essentially force-accumulators, while animals are force-dissipators; and it is from the plants that the animal derives his physical powers. A plant, like an animal, possesses powers of locomotion; and gives proofs of the development of force in the lifting up of the materials which are necessary for the building up of its structures from the ground to its highest branch, as well as in numerous other ways; but such displays are due to purely physical causes, such as capillary attraction, osmosis, and the like. In the animal, on the other hand, the force is far more highly concentrated, and is mainly due to the power developed by the formation of a chemical compound, viz., carbonic acid. Under Carbon, E. C. S., we have pointed out the enormous force with which the carbon and oxygen are held together, and have also indicated that the only way in which the separation of these two elements is effected on a large scale in nature, is by the combined action of the atmosphere, plants, and sunshine. The atmosphere yields the carbonic acid; and the plant, in union with the sunshine, brings about the separation of the elements in a way which we do not understand, and so quietly that we can hardly realise the amount of work that is being done. Most of the oxygen is liberated, while the rest of it remains behind in union with carbon and hydrogen. The source of the hydrogen is water. These three elements, viz., hydrogen, oxygen, and carbon, form the large proportion of all the tissues of plants and animals. There is also a fourth element, namely, nitrogen, which enters into many plants and animals, but which is more general in animal than in plant tissues. The plant derives it from some nitrogenous compound, probably ammonia. Starting with the simple substances, water, carbonic acid, and ammonia, which constitute the food of plants, we might trace how step by step the carbon, oxygen, nitrogen, and hydrogen are built up into molecules, remarkable for the variety of their constitution and complexity, but almost all agreeing in containing a large proportion of carbon. When these compounds are eaten by animals, they undergo an inverse series of changes, whereby they are again finally reduced to water, ammonia, and carbonic acid. Hence we frequently find the same chemical compound in both animals and plants: in the latter it is formed by synthesis, and represents a stage in the building up of more complex molecules; in the former by analysis, and represents a stage in the process of the destruction of such molecules. It would take us beyond our limits to describe the processes by which these alterations are effected; suffice it to say that the chemist has succeeded in imitating many of them. He has been able not only to effect what the animal does in reducing the more complex carbon-containing molecules to simpler ones, but even to build up many of the compounds found in plants from their elements. He has succeeded in forming many of those substances which it was at one time supposed could only be formed by the direct agency of life, or vital force. Passing by these subjects, the main fact which concerns us is that plants are carbon accumulators; and animals carbon dissipators. This has a direct relation with the fact before mentioned, that plants store up force, and animals expend it. Plants derive extraneous power from the sunshine which enables them to separate the oxygen from its compounds; and plants, we know, are deoxidizing agents, for they consume carbonic acid and emit oxygen. Animals, on the other hand, utilise the power derived from the oxidation of their carbon compounds; and we know they are oxidizing agents, for they inspire oxygen, and expire carbonic acid. Thus we perceive that plants, animals, and what are termed inorganic substances or minerals, are so intimately connected, that they appear to be parts of the same great scheme, rather than independent members of creation.

The chemist is gradually but surely revealing to us the ways in which organic compounds are formed, and is enabling us to understand the laws which regulate such formation. He has gone far to dissipate the old notion of the mysterious powers of vital force, by means of which only could such compounds be constructed, and arranged in their proper place in the animal system. The combination of elements into organic compounds is no more dependent upon vital force than the formation of carbonic acid in our fireplaces, or any other compound which is generally considered to belong to inorganic chemistry. And there is no proof that the arrangement of these compounds into bones, muscles, and other tissues; the grouping of these tissues into organs; and the marshalling of these organs into plans of structure, is the work of any special vital force. No doubt there is a power by which all this admirable co-ordination is effected, but we cannot trace it to any special force, whether it be electricity, magnetism, chemical affinity, or any recognised force in nature. Moreover, the kind of action attributed to vital force is not confined to living organisms, whether animals or plants, but is perceptible in everything that comes within man's cognizance. This power is as perceptible in the building up of a crystal as in the creation of a man, and consists in the application of forces to effect a given purpose. Vital force, indeed, appears to us to be another name for the great Ruler of the universe, and it is the great object of zoologists to ascertain, as far as may be permitted to them, what are the modes of thought and action, and what the purpose of the great Master Mind, as displayed in the animal kingdom. To use the words of Professor Owen, zoology "seeks to guide or help to the power of apprehending the unity which underlies the diversity of animal structures; to show in these structures the evidences of a predetermining Will, producing them in reference to a final purpose; and to indicate the direction and degrees in which organization, in subserving such Will, rises from the general to the particular." This is said with reference to the object of his work "On the Anatomy of Vertebrates," but we have applied the statement to zoology, thus departing somewhat from the letter of the quotation, without, however, taking away from its spirit. In the preface to the same work, the Professor has given so concise an account of the objects of zoology, that we venture to quote it:—

"An animal may be dissected in order to a knowledge of its structure absolutely without reference to or comparison with any other, its species being regarded as standing alone in creation. The knowledge so gained, from the limitation of the field of inquiry, may be most accurate and minute, most valuable in its application of the repair of injury and decay, and the cure of disease. Such, *e.g.*, is Anthropotomy, or the anatomy of man, and Hippotomy, or that of the horse. Besides the numerous and excellent works on these special subjects, I may cite the 'Traité Anatomique de la Chenille de Saule,' 4to, 1762, by Lyonnet; the 'Anatome Testudinis Europeæ,' fol., 1819, by Bojanus; the 'Anatomie Descriptive du *Melolontha Vulgaris*,' 4to, 1828; and the 'Anatomie Descriptive du Chat,' 4to, 2 vols., by Straus-Durckheim; also in application of the science to art, 'The Camel; its Anatomy, Proportions, &c.' 1865, by Elijah Walton; as unsurpassed examples of this monographical kind of anatomical science. As applied to man it is commonly called 'human anatomy,' and is, in strictness of speech, one of the manifold ways of human work. But the anatomist may apply himself to a particular organ instead of a particular species, either exhaustively in one animal, or by tracing such organ or system throughout the animal kingdom. The 'neurotomies' and 'neurographies' to which Joseph Swan, *e.g*, has devoted a life, the 'Osteographie' of De Blainville, and my own 'Odontography,' are examples of this way of anatomy. John Hunter assembled the evidences of his labours in the unique and grand department of his museum illustrative of anatomy, properly so called, in series according to the organ, beginning with the simplest form, followed in succession by the progressively more complex conditions of the same organ, the series culminating, in most cases, with that which exists in the human frame. The mechanism of the organ was here unfolded, and its gradations were compared, to discover its mode of working; and as physiology mainly consists in such determinations of functions or final aim, this kind of investigation of organic structure might be termed Physiological Anatomy. Homological anatomy seeks in the characters of an organ and part those, chiefly of relative position and connections, that guide to a conclusion manifested by applying the *same name* to such part or organ, so far as the determination of the namesakeism or homology has been carried out in the animal kingdom. This aim of anatomy concerns itself little, if at all, with function, and has led to generalizations of high import, beyond the reach of one who rests on final causes. It has been termed grandiloquently, Transcendental and Philosophical; but every kind of anatomy ought to be so pursued as to deserve the latter epithet. A fourth way of anatomy is that which takes a particular species in the course of individual development, from the impregnated ovum, tracing each organ step by step in its evolution up to the adult condition. It is called Embryology and Developmental Anatomy. A fifth way of anatomy is that which investigates the structure of an animal in its totality, with the view of learning how the form or state of one part or organ is necessitated by its functional connections with another, and how the co-ordination of organs is adapted to the habits and sphere of life of the species; but does not stop here, having for its main end the comparison of these associated modifications and interdependencies of organ in all the species of animals. As their degrees of affinity and the characters and circumscription of natural groups are hereby illustrated, this way may be termed Zoological Anatomy. In the hands of the anatomist the microscope has been mainly applied to the constituent parts of an organ, called tissues; and the results of such research, combined with those of chemical tests, constitute a sixth sort of anatomy, called Histology. It has been termed Microscopical Anatomy; but this is essentially only a more refined method of the scrutiny of organic parts. In so far, however, as Histology treats of structure according to the proximate tissues common to different organs, it corresponds with the branch of the science which Bichat, its founder, called, loosely, 'Anatomie Générale.' Finally, a seventh way in which the highest generalization in biological science may be aimed at, is that which is taken when we pursue investigations of form and structure beyond the animals that *are*, to those that *have been*. Here, however, the anatomist is limited, as a rule, to such tissues and organs as are petrifiable, *e.g.*, corals, shells, crusts, scales, scutes, bones, and teeth; but he has been stimulated to a degree of minuteness and accuracy of observation in this field of research to which few of the other ways and aims would have led him. In applying the results of such researches to the restoration of extinct species, physiology has benefited by the study of the relations of structure to function requisite to obtain an insight into the food, habits, and sphere of life of such species; and zoology has gained an immense accession of subjects through such determinations, with improved systems of classification due to the expanded survey of organic nature opened out by Palæontology."

Articles illustrative of each of these modes of investigation will be found in this Supplement. General remarks on classification, which form a part of the E. C. article, will be more conveniently considered under ZOOLOGY, in the Supplement. There are two other subjects of great interest, viz., PALÆONTOLOGY, and the GEOGRAPHICAL DISTRIBUTION of ANIMALS, which seem to require special headings, and therefore nothing will be said about them here.

ANKERITE is a variety of dolomite, in which iron and manganese have partially replaced the magnesium. Its hardness is about 3·5 or 4, and the specific gravity from 2·95 to 3·1. It has been found near Torness, in the Orkneys; and in some localities near Whitehaven.

ANNELIDA [E. C. vol. i. cols. 205—213]. There are few classes in the Animal Kingdom about which more information has been acquired during the past ten or fifteen years than the Annelids. At one time the study of them was comparatively neglected; but of late years large collections of species have been made in various parts of the world, and the result of their examination has been the addition of hundreds of generic forms, about which nothing whatever was previously known. So rapidly are important facts being published by Claparede, Ehlers, Kinberg, Malmgren, Schmarda, Quatrefages, and others, that more than usual caution is required in making general statements; and this remark, perhaps, applies more especially to their geographical distribution. To give some idea of the great alterations that have been made in the number of annelids known, it may be noticed that the class Annelida, as defined by Quatrefages, was grouped by Savigny into 7 families; Johnston raised the number to 17; Grübe, in 1851, recognised 19; Schmarda, 21; and Quatrefages, in 1865, 26. We find also that the genera present the same gradual increase. In 1820, Savigny recognised 26; Lamarck, 49, in 1838; Grübe, 86, in 1851; Schmarda, 97, in 1861; Quatrefages, 245, in 1865; while since then at least 30 or 40 have been added by Malmgren, Kinberg, and others. The species also have been increasing at the same rapid rate. Thus Kinberg alone trebled the number of species which were known before he began his recent investigations. As a compiler, we ought to examine and digest all this new material, but as the task is too time-absorbing, we cannot attempt it. This is fortunately not of very great importance, since an excellent *résumé* of the state of our knowledge in 1865 respecting Annelids was recently published by Quatrefages in a work forming part of the 'Suite à Buffon', and having for its title, 'Histoire Naturelle des Anneles marins et d'eau douce. Anneles et Gephyreens.' This work will in the main form the basis of this article. When we treat of the classification of the class, its limits will be indicated; at present, it will be sufficient to say that the class *Annelida* of Quatrefages is nearly coincident with the orders *Dorsibranchiatæ* and *Tubicolæ* of Milne-Edwards. The other two orders assigned to the class in the E. C. article, viz., *Terricolæ* and *Suctoriæ* are not considered to belong to the Annelidan class.

Annelids are creatures in which the two sides of the body are similar, both externally and internally. This feature is combined with an annulated or ring-like structure, in which the amount of repetitive similarity varies from group to group. Taking the class as a whole, we may recognize three principal regions, viz., the *cephalic*, the *thoracic*, and the *abdominal*.

All annelids have a cephalic region. It consists of two parts, which have been termed the head or cerebral ring, and the buccal ring. The cerebral ring is present in all annelids, although in some, as the *Terebellidæ*, it is represented by a very small protuberance. The buccal ring is considered by some observers to be the first thoracic ring, but since the mouth is always situated on this ring, we may safely consider it to be a part of the cephalic region. The mouth is always placed in the head in all animals which have that part distinctly marked off. Moreover, the internal structure of the parts confirm the interpretation suggested by Quatrefages. Amongst the *Errantes*, the cephalic appendages vary considerably in number, form, and position. They have been named in an arbitrary manner, and without special attention to their morphological position. Hence it has happened that considerable confusion has been introduced into their nomenclature; the homologous parts receiving different names in different species, while on the other hand analogous parts have received the same name. The system of naming should be uniform, and should be regulated by the position of the appendages. By *antennæ* is meant all the appendages of the head proper; they are supplied with nerves originating in the brain. The *tentacles* are always situated on the buccal ring, and are supplied with nerves from the connective. The *tentacular cirrhi*, are those appendages of the first feet which have the character of tentacles or antennæ, and which are supplied with nerves from ganglions in the ventral chain. The antennæ vary in number from 1 to 5, but generally they are 2 or 4. Their form varies from short conical to long filiform processes. The tentacular cirrhi are generally more slender and of greater length, but in many cases they are not to be distinguished from the antennæ or tentacles, as regards form. They are all organs of sense, probably of touch; and are never retractile or exsertile. Amongst the *Sedentaria*, the cephalic appendages are very much modified, but Quatrefages thinks the prehensile cirrhi of the *Terebellæ* represent the antennæ of the *Errantes*; the respiratory organs of the *Sabellidæ* and *Serpulidæ* are modified cephalic appendages; and the opercular apparatus of the *Hermellidæ* correspond to the tentacles. In most species of the Sedentary worms, the buccal ring has no appendages.

The thoracic region is found in almost all the *Sedentaria*, whereas it occurs in few, if any, of the *Errantes*. It generally consists of a small number of rings, each of which has a pair of feet, and generally some of the anterior rings have respiratory organs in addition.

The abdominal region is universally present, and comprises a large number of rings similar or only slightly dissimilar amongst themselves. The last ring is, however, always different from those that precede it. It never has feet like the other rings, but long cirrhi which have some analogy in form to those on the head. In the *Sedentaria* the posterior part of the body is so modified, that it has been proposed to consider it as a distinct region under the name of the *caudal region* or *tail*; it has no appendages, very faint indications of annulation, and a general simplification of organization as compared with other parts of the body. The respiratory organs are placed on various regions: sometimes on the head, as in the *Serpulæ*; sometimes on the thoracic region, as in the *Terebellæ*; sometimes on the abdominal region, as in the *Arenicolæ*; and sometimes on both the thoracic and abdominal regions, as in the *Hermellæ*. There are a few exceptional groups, such as *Polydora* and *Chætopterus*, in which the distinction of regions is not well defined.

In its simplest form, the foot is a hollow process bearing a number of setæ, which setæ are connected with a series of muscles. Such a foot is said to be *uniramous*. Sometimes the foot is formed by two hollow processes, in which case it is *biramous*; the upper process is the *dorsal ramus*, and the lower, the *ventral ramus*. The feet of some of the annelids, however, have a more or less complicated array of accessory parts, some of which are subservient to purposes of touch, while others are organized for respiration; and in a few instances the same part performs the functions both of touch and respiration. The organs of touch are cirrhi, generally longer than the setigerous part of the foot, and are mostly implanted at the base of a ramus. The respiratory organs vary from richly vasculated processes as in the *Nereids* to the arborescent tufts of *Arenicola*. The *elytra* of *Aphrodita* and its allies are respiratory organs; they are flat scales, within which is a space communicating with the general cavity of the body.

The body is also furnished with epidermic and dermic growths. They are of different kinds, and perform different functions, and hence it is desirable to distinguish them. Quatrefages separates them into two groups; but this is a matter of convenience, since the groups are connected by intermediate varieties which can be assigned to neither.

The first comprises the parts which have their origin in the epidermis only. They are generally exceedingly small, very slender, but somewhat rigid, in which respect they differ from vibratile cilia. These are called *hairs*. In *Sabella* they attain a considerable length, and it is probable that the hairs which cover the whole surface of *Aphrodita* belong to this group. There are a series of intermediate excretory products which differ from the hair, properly so called, inasmuch as they are hollow, and the derm partially enters into their structure. The second group comprises the *setæ*, which are developed from special glands in the derm. They are usually tough and shiny, and present almost every imaginable variety of form. Some are adapted for pricking, some are hooked for the purpose of clasping, others have a sharp cutting edge, or a serrated edge. Modifications occur by which they acquire a more lax form, and then their spatulate or pennated shape subserves the purposes of natation. Each of these has a name appropriated to it.

The skin of all annelids consists of two layers: the *epidermis* and the *dermis*. The epidermis is in most cases formed of two sets of fibres crossing each other; and it is this arrangement, combined with the close contiguity of the fibres, which produces the iridescent colouring observable in many annelids. The dermis is of a granular texture, and is the seat of the pigment which imparts the colour to the superficial parts of the body.

In most annelids there are two muscular layers; the upper has the muscular fibres arranged across the body, while in the lower they stretch longitudinally from one interannular septum to another. This second layer is generally very thick in the anterior portion of the body, and comparatively thin in the posterior portion. The fibres are arranged side by side, and are neither separated by nor imbedded in a cellular tissue as is the case amongst vertebrates. Hence it happens that the ova are frequently found entangled amongst the muscular fibres in annelids. The rings or segments are separated by valves or septa, having a fibro-muscular structure, but the degree of muscularity differs considerably according to the species. Each septum is pierced with an aperture through which the digestive tube passes. In certain species, the digestive canal is soldered to the edges of the apertures of the fore-part of the body, so that the anterior segments are closed chambers ; but in the majority of cases there is a greater or less space between the digestive tube and the walls of the orifice which allows of the passage of the fluids of the general cavity of the body from one segment to another. In some cases the septa are reduced to a few muscular bands, which keep the digestive tube in position. In addition to these there are in some annelids a septum which divides the chambers lengthwise into stories.

The general cavity of the body forms by far the greater proportion of the bulk of most annelids. It is, as has already been intimated, in direct communication with the spaces between the muscles. It is also continuous with the hollow parts of the feet and buccal appendages ; with the interior of the elytra of the Aphrodite family, and of the branchial apparatus of *Serpula* and *Sabella*. It is lined throughout with a homogeneous, slightly cellular tissue, which appears to be essentially a peritoneum. It is filled with a fluid which is rarely coloured, and which contains transparent globules, whose abundance seems to have some relation to the vigour and energy of the individual. The form of the globules is irregular, or oval, or spherical. In *Apneumea* and *Ancistria*, they have a reddish tinge. The fluid is kept in constant motion by the contraction and dilation of various parts of the body, and by vibratile cilia on the inside of the foot cavities. A very few annelids have a well-developed vascular system ; this fluid probably contains the liquids which represent the serum, lymph, chyle, and blood of the vertebrates all mingled together. If so, it may be regarded as the nourishing fluid of the system in annelids.

The digestive system consists of an alimentary canal with appendages. This canal extends the whole length of the individual, from the buccal to the ultimate or penultimate ring. It is seldom longer than the body, in which case it is straight ; but in a few genera, more especially *Chlorœma*, it is longer, and is consequently more or less folded and convoluted. In the most highly specialized digestive system, there may be recognised a mouth (*bouche*), with its buccal cavity, a proboscis, an œsophagus, and an intestine.

The term *bouche*, here translated mouth, refers to the opening in the skin, which may or may not be provided with lips. It leads into the buccal cavity, the walls of which are composed of three layers ; viz., a mucous membrane or innermost tissue, next a muscular layer, and outside this a continuation of the peritoneal layer. The *proboscis* comprises all that is situated between the buccal cavity and the intestines, and a specialized portion of this is further distinguished as the œsophagus. The proboscis presents a great variety of form and structure. In the Nereids, which possess it in its most typical form, three regions are recognisable, viz., the *pharynx* in front, a *dental region* in the middle, and the *œsophagus* behind. The pharynx occupies the first three or four rings of the thoracic region, and its wall is formed of a mucous, a fibrous, a muscular, and a peritoneal layer. Sometimes it has a number of small horny, brown denticules which are simply implanted in the fibrous layer, and are unprovided with special muscles for moving them. The dentary region is at once recognised by its swollen and highly muscular appearance. The muscles form two antagonistic masses, one of which pulls apart the anterior edges of the teeth, and the latter brings them together. The teeth are imbedded in the muscles. They are of a horny nature, and of a brown colour. They are hollow, and in this hollow a powerful muscle is inserted. The dental organs are of two kinds : one is large and moved by muscles, and these are the teeth proper ; the other is small and is moved by the general motion of the proboscis, not by special muscles, and these are *denticules* or *teethlets*. The teeth and teethlets are further distinguished by names, according as they are spiny, serrated, &c. The *œsophagus* is separated from the preceding region by a strong muscle, which attaches the digestive canal to the sides of the body. The muscles of the œsophagus are very powerful, and arranged longitudinally ; they diminish in thickness from before backwards. In the anterior portion, and frequently buried amongst the muscles, are two glands which will be mentioned again presently. The œsophagus has its form constantly changed by the action of the muscles ; but in the ordinary state it is straight, cylindrical, and longitudinally folded. In passing from group to group, the proboscis undergoes considerable alteration, which generally consists of the gradual disappearance of one part after another, rather than of the simple modification of those parts. The degree to which the proboscis can be exserted varies. In some it is not exposed at all beyond the mouth, while in the genera *Nephthys*, *Phyllodoce*, and *Glycera*, it is projected far beyond it. This extroversion is mainly effected by the muscles of the body propelling forward the fluid of the general cavity. In this way the proboscis is turned inside out. The retraction is effected by the muscles of the proboscis itself. The *intestine* is usually wider than the proboscis, and has a far less powerful muscular apparatus. Its wall is similar to that of the proboscis, but the layers are thinner. It possesses, however, one additional part in the form of a hepatic layer. Its form is more or less beaded, owing to its dilation in the interannular spaces. In the *Chlorœma* family, the intestine is remarkable for its length and accessory cæca. The same part also has a remarkable structure in the Aphrodite family. The intestine gives origin to a series of cæca which are arranged under the skin of the back. They are separated at will from the main intestine by sphincter muscles. The anal aperture is placed on the ultimate or penultimate ring, and is mostly situated on the dorsal surface, though in a few genera, such as *Terebella*, it is terminal.

The appendages of the intestine are of two kinds, viz. : the salivary glands and the liver. The former probably exist in all annelids, but their position and number vary. Thus amongst the *Syllidæ*, they are situated at the posterior extremity of the œsophagus. In *Glycerea* they occur at the junction of the pharyngeal and œsophageal regions of the proboscis ; and in the Aphrodite family, at the junction of the œsophageal and dental regions. The Nereids have one pair ; *Glycerea* two pairs, and *Terebella* three. There are also variations as regards structure. Amongst the Nereids they are more or less elongated, swollen cæca, having a brownish or greenish colour, enveloped in a muscular tissue, and having internally a very elegant plexus or network, in which is a transparent liquid. Amongst the *Syllidea* they are more or less transparent small pits. Among the *Glycereæ*, each gland is contained in an oblong sac communicating with the œsophagus, and containing a white corpuscle. Amongst the *Aphroditea* the glands consist of a number of greenish-yellow cæca within a large pouch, the inner surface of which seems to have a secreting function. When the glands are conspicuous their orifices are readily detected ; but sometimes they form a layer only in the thickness of the walls of the proboscis, in which case the orifices are not distinguishable. The liver is not a distinct organ among annelids ; but is represented by a brownish layer in the wall of the intestine. Sometimes the layer is confined to particular spots ; and sometimes it is continuous over a large proportion of the intestine.

Digestion is apparently effected in the same general way in annelids as in other animals. The food is collected in a ball in the mouth, and passed on from segment to segment, with a delay of a certain duration in each segment. During its course it is kept in constant agitation by vibratile cilia, and thereby broken up into minute granules, as small as the $\frac{1}{1000}$th of a millimetre in diameter. At the penultimate segment the pause is longer than in the others : it is not agitated by cilia when there, but remains still until discharged from the body.

The circulatory system of annelids presents so much variation in its arrangement, that it is difficult to say what the general plan is. The nearest approach to what is considered as the typical arrangement is afforded by *Hermella*. In this genus there is an upper and a lower vessel on each side of each segment. Between the two is placed a branchia. The blood on leaving the branchia passes into the lower vessel, and through it to all the tissues which require nourishment from it, such as those on the abdominal walls, the feet, and the subcutaneous muscles. It then returns, accumulates in the upper vessels, and then proceeds to the branchia to be again oxygenated. There are in this case, four main trunks, of which two are above and two below. The former two are filled with venous blood, and represent functionally the *vena cava ;* the latter two are charged with arterial blood, and may be regarded as the representative of the *aorta*. The two lower trunks are connected here and there by transverse branches. This arrangement, however, is restricted to certain segments, since the two upper and the two lower vessels are fused together in the pectoral and caudal regions.

In *Marphysa*, the two upper, and in *Leucodore*, the two lower trunks are amalgamated together in one portion of the body. In some genera the upper or the lower trunks are completely fused. Thus in *Nephthys* there are two lower and only one upper trunk. In the great majority of annelids both the upper and lower trunks are amalgamated, so that they possess but one trunk above and one below, each situated in the median line. The subsidiary vessels present their simplest phase in *Leucodore*, in which there are two vessels, while no ramifications connect the abdominal and dorsal trunk in each segment. A similar arrangement occurs in *Phoronis*. In most annelids, however, the connection is more complicated ; and examples occur in which the subsidiary arteries and veins are highly ramified and are connected by an intermediate system of capillaries. In many of the larger species there is in addition a complicated network of blood-vessels covering the digestive canal. The nerves are always accompanied by blood-vessels, which are more complicated in proportion to the size and importance of the nerve. Thus, the brain is frequently accompanied by a highly complicated network. There are, however, annelids in which the blood vascular system is less developed than in *Hermella*, or in which this system is degraded, to use Quatrefages' expression. Thus in *Apneumea* there are no blood-vessels at all ; and the same is the case with *Glycera*, and probably other genera. Whatever may be the arrangement of the vascular system, some means is required to propel the blood. This is sometimes effected by the contraction and dilatation of the vessels themselves, but sometimes by the alternate movements of one or more enlarged portions of the trunk, which are termed *hearts*. *Terebella*, *Hermella*, and *Chlorœma* are examples. In *Arenicola* and *Polyophthalmus*, the so-called heart is a more specialized organ. It is seated in the course of the main trunk. There is a chamber for receiving the blood coming from the intestines, which Quatrefages calls the auricle ; from this it passes to two distinct cavities called ventricles, whose contractions propel the blood through the whole body.

The blood, or the fluid which flows through special canals, is colourless in most of the small species, and is almost colourless in many of the larger ones. In some the colour is green, as amongst the *Sabellidæ*, of which, however, one species, *Sabella saxicava*, has red blood. Cuvier attached great importance to the red colour of the blood, but it is by no means general amongst the annelids. Moreover, the blood when red is essentially different in its nature from the red blood of vertebrates, and the reason why Cuvier set so high a classificatory value on this character probably arose from his considering the red blood of annelids to be very similar to that of the vertebrates. The colour of the blood in annelids is due to the solution of some colouring matter, and not to the presence of coloured globules. In one or two cases it is due to the presence of such globules. The blood of annelids coagulates very readily. Its motion when in the body is from behind forwards in the upper vessels, and in the opposite direction in those at the lower level. In each segment there is normally a definite course, so that one portion of the blood is venous and the other arterial in the branchiferous species.

The aëration of the blood is effected either by branchiæ, by specialized portions of the skin, or by the general surface of the body. The branchia consists essentially of a central canal communicating with the afferent and efferent vessels, and is frequently lined by special walls. It is enveloped in a transparent granular layer, in which is a series of ampulliform cavities. Outside this is the epidermis supporting ciliæ and hairs. The shape varies from a simple lobe or tongue in *Hermella* to a multifid one in many species of *Eunice;* long cirrhi in *Cirrhatula;* and ramified bushes in *Arenicola*. In some species they are pinnated or bipinnated, fasciculated or flabelliform. In the *Sabellæ* they are supported by a cartilaginous framework. The structure or degree of development of the respiratory apparatus is a character of little importance in annelids. The same generic group may have species with atrophied or with highly developed organs. In the non-branchiated species the skin appears to be the principal seat of respiration, and it is very probable that in those species which have branchiæ the skin is an important auxiliary. Respiration is also carried on to a greater or less extent by the fluid of the general cavity of the body, and in those species which have no blood-vessels, this fluid is seen to have true blood globules. The aëration of this fluid is frequently facilitated by its passage up and down long filiform cirrhi.

The skin is an active secreting agent in annelids ; and the nature of the secretion varies. It is by it that are formed the calcareous tubes of *Serpula* and *Protula ;* the parchment-like tube of *Chætopterus*, and the soft membrane which enters into the tubes of *Terebella*, &c. Many of the *Errantes* are able to form a sort of web or a layer like collodion in the course of a few minutes. Quatrefages mentions a case in which a *Lumbrinereis* in a plate of water secreted a layer of hyaline appearance while it was being sketched by the artist. The layer possessed considerable density and hardness, and exceeded the annelid itself in bulk. The peritoneal membrane is also an active secreting organ, but the products are generally soluble in the fluid of the general cavity.

The nervous system comprises two distinct parts, each of which Quatrefages terms a system. They are the *general* and the *stomatogastric*. The general system consists of the brain and the ganglionic chain. The first is placed above the digestive canal and in the head. The second is below it in all the rest of the body. The two are connected by a pair of nerves which surround the œsophagus, and which are hence termed the œsophageal connectives, but would more appropriately be termed buccal, since they are always in the buccal segment. The typical arrangement occurs in *Sabella*, in which there are two distinct main nerves running the length of the body. In each segment each nerve has a ganglion from which originate the nerves supplying the peripheral portion of the body. The brain also consists of two lateral halves ; but these, as also the ganglion in each segment, are connected by commissural bands. This distinctness of the two lateral systems is not general ; indeed they are usually more or less fused together. In *Hermella* the two cerebral halves are amalgamated. There is, however, always a trace of the typical division, even in those species which have the most concentrated nervous system, in a deep groove which traverses the central line of the ganglionic chain. In the majority of species the ganglionic chain is more or less divided. Amongst the most highly organized annelids such as the *Aphrodita*, *Eunice* and *Nereis* families, the ganglions form flat ovoidal masses, and the connectives are united together, although they still retain, especially in the hinder segments, traces of the primordial division. The nerves consist of a thick fibrous membrane, and of a pulpy matter of the consistency of jelly. The latter consists, in some species, of an inner white substance surrounded by a brown layer.

The sense of touch appears to be well developed in annelids, and seems to reside more especially in the feet, and in the interannular spaces. It is probably to touch that the branchiæ of *Serpula* and *Sabella* owe their remarkable sensitiveness. The cautious movements of these creatures seem to imply the possession of a tactile sense ; and the antennæ and cirrhi appear to be organs especially adapted for feeling. What but touch can enable the *Terebella* to collect the materials for its tube by means of cirrhi, which are seen to stretch for a considerable distance and to select the fragments of sand, shell, &c. The *Pectinaria* again always forms its tubes in the same way with grains of sand. This implies a methodical choice of material and a keen tactile perception. From practical evidence alone it would be doubtful if annelids are able to appreciate sound, since no noise, which is unaccompanied by a vibration, seems to have any influence on them. Some species, however, do possess what is considered to be an auditory organ. It resembles the same part in mollusks, and consists of a capsule filled with a fluid, in which fluid is suspended one or more granules or otoliths. These otoliths are in a state of constant tremor, although there are no visible signs of vibratile cilia. Moreover, a special nerve is given off to each organ, the end of which nerve is expanded so as to envelope it with a finely granular tissue. Many species have distinct organs of vision, but they are best developed in *Torrea vitrea*. The thin diaphanous portion represents the transparent cornea. Beneath it is a fibrous layer forming a true sclerotic layer, continuous with the optic nerve. This sclerotic has a large aperture partially closed by a reddish brown choroid. In its centre is a pupillary opening which surrounds a bright blue circle. Through the pupil may be seen the interior of the eye lined with a choroid, having a trellis-like structure. This globe is filled with a perfectly transparent vitreous body in which is suspended a spherical crystalline lens. This eye is clearly adapted to receive impressions of images. But in many annelids the crystalline lens is absent, in which case there is probably only a perception of light and darkness. This remark applies to the *Hermellæ*, *Terebellæ*, *Sabellæ*, and some other genera. In most species the eyes are situated within the head ; but in some they are placed in other positions. Thus in *Polyophthalmus* there are in addition to three eyes in the head, two on each segment of the body. In *Amphocorine cirrata* there are two in the head, and two on the last segment. In *Amphicorine argus* there are two rows of eyes in the head, numbering altogether 24 or 28 ; there are also 10 rows on the last ring, and two pairs on each segment. In *Sabella*, properly so called, there are a certain number of eyes with crystalline lenses at the bases of the branchial tentacles.

All the annelids, with the exception of *Phoronis*, possess feet. They are the special locomotive organs; but the subcutaneous muscles act as important auxiliaries. The *uncini*, or hooked setæ, are used mainly for movements in burrows and tubes. From the soft nature of the annelids there is an entire absence of any hard parts capable of acting as fulcra for the application of muscular force; but this want is compensated for by the general cavity filled with fluid. This cavity is surrounded on all sides by muscles, and can be enlarged or diminished at the will of the animal. In the first state the body is soft, and the body walls yield with the slightest exertion of muscular effort. In the second state the fluid-filled cavity being subjected to great pressure becomes rigid and then the integuments become as serviceable bases of support for the muscles as the horny envelopes of insects. It is by the efflux and reflux of this liquid that the feet are put in motion. The muscles in the feet are only serviceable for moving the setæ. The presence of this liquid and the consolidation of the foot-walls by pressure are quite as necessary for the swimming as for the crawling annelids. For instance, the large flaps of *Heteronereis* would be quite unable to resist the water if they retained the natural pliability of the tissues composing it: but it will subserve this purpose when made rigid by the penetration of the fluid.

There are also some accessory organs of locomotion. Amongst them are the long cirrhi of many *Sedentaria* These cirrhi are generally hollow, and provided with longitudinally fibred muscular walls; but in *Hermella* no muscles are seen, and yet the cirrhi in the species of this genus are extended and retracted, flexed in various directions, and even coiled round objects. This is accounted for by Quatrefages by the communication of the hollow part of the cirrhi with the general body cavity, enabling extension to be effected by the propulsion of fluid. In most *Sedentaria* the flexion is effected by the longitudinal muscles. The cirrhi are attached to objects, and when retracted the body of the annelid is drawn forward.

The surface of the body of some annelids has vibratile cilia on certain parts. The bases of the feet, as well as the under surface of the head, are nearly always more or less furnished with them. In some groups a band of them extends down the centre of the ventral surface, and are probably not without some influence in locomotion. But in two genera they are still more developed, and form a rotary apparatus which aids locomotion. In *Dujardinia* each ring has an umbilical tubercle, the edge of which is provided with a row of very long cilia, by whose aid the creature glides slowly through the water. In *Polyophthalmus* the apparatus effects locomotion at the same time that it brings food to the mouth. It consists of two pads covered with cilia on the sides of the buccal ring, and can be expanded or folded up, as in the Rotifer. It is expanded by the action of the fluid of the general cavity, but is drawn in by special muscles.

The reproductive organs are alike in both sexes, and can only be distinguished by the difference of their products. The ovum first appears in *Hermella* as a sphere $\frac{1}{800}$ *mm.* in diameter, which gradually increases to $\frac{1}{500}$ *mm.* At this period a small corpuscle is seen in its interior. The sphere is the germinal vesicle, and the corpuscle is the germinal spot. The egg is then detached and discharged into the fluid of the general cavity, where it floats about. When the germinal vesicle has acquired a diameter of $\frac{1}{50}$ *mm.* it is enveloped in a thin membrane. Between this membrane and the germinal vesicle accumulates a homogeneous liquid, in which granules form and multiply, and these granules represent the rudiments of a yolk. All the parts grow, and the yolk acquires colour. When the egg has attained its full dimensions it has a pale violet tint by reflected, and a greenish yellow by refracted, light. At this time its diameter is $\frac{23}{500}$ *mm.* It is probable that the phenomena are very similar in all the other genera. When the egg has been fecundated certain motions ensue, which result in the expulsion of a transparent globule whose nature is unknown. In *Hermella* the process occupies about an hour. Immediately after, the segmentation of the yolk commences. The segmentation is neither regular nor constantly progressive, but division, nevertheless, still continues. In six or seven hours the egg acquires a mulberry aspect. At this period the yolk consists of two parts. The external, losing its yolk-like aspect completely envelopes an internal nucleus, in which this character is retained. The first rapidly assumes the characters of young tissues. The second forms large cellules, in the midst of which is a space which is continued to the surface of the yolk, where is an irregular triangular or quadrangular area, which ultimately becomes the site of the mouth. During this second period, which lasts about eight hours, the covering membrane undergoes no change, except irregular plication. Immediately after the mouth has appeared, the eggs commence a series of quick irregular oscillations, currents appear, and soon after the cilia are recognisable. The cilia are inserted on the ovarian membrane, which ultimately becomes the skin of the embryo. The embryo is now oval in shape, and has a small, smooth, finally globular papilla at each end. The remainder of the body is covered with cilia. The mouth is scarcely terminal, and its position indicates what will be the ventral surface. The digestive tube is marked out. The large granules become detached from the other tissues, and form in lines where the walls of the intestine are to be. At this stage the embryo is quite as advanced as the embryo of *Terebella*, observed by Milne-Edwards; but there are no indications of the disposition of the cilia in bands in *Hermella*, as noticed by Milne-Edwards in *Terebella*. From this time onwards the cilia gradually disappear; tentacles and eyes are developed at the fore end; and setæ increase in size and number in the posterior parts. Beyond this stage Quatrefages was unable to carry his observations. It is noticeable that the whole of the ovum is incorporated in the individual, and the same thing appears to be the case in *Protula* and *Polynoe*. In *Cystonereis* and *Exogone* it would seem that the individual is formed from the blastoderm only. In the growth of the individual the new rings appear between the ultimate and penultimate segments.

The annelids are especially interesting on account of their many and remarkable modes of reproduction. These may be conveniently arranged in two sections, the one comprising ordinary genesis, or by means of eggs, and the other those cases in which the young are developed without the direct intervention of eggs, or *geneagenesis*, as Quatrefages proposes to call it. Fissiparity, or the spontaneous division of the body into parts that become developed into complete zooids, is one form of *geneagenesis*. It has been observed in *Myrianida*, *Autolytus*, and *Filograna*. The separated zooid consists either of the individualization of a portion of the parts, or of newly-formed parts, or of a combination of the two. In *Syllis amica* (better known by the name it long retained, *S. monolifera*), the second mode occurs; in *Protula dysteri* the third mode obtains; and in *Exogone gemmifera* the mode of reproduction is by true gemmation. In a species of *Syllis* observed by Vaillant there is yet another mode of reproduction.

In animals possessing such powers as these we should naturally look for great reparative faculties, but it is only recently that any facts have been brought forward to confirm this supposition. Van Beneden has seen a *Serpula* reproduce the greater part of its body. Similar facts have been recorded of *Phoronis*. Species of *Marphysa* frequently reproduce their hinder segments, and it seems evident that the restoration of lost parts is frequent, since many individuals are always to be found with a greater or less number of the hinder rings lighter and narrower than those of the rest of the body. These light coloured rings are of recent formation, and have doubtless replaced others which have been lost. It is not unlikely that the hinder rings are occasionally snipped off by enemies when the annelid is retreating into its gallery. But it has been well established that they are thrown off by a spontaneous rupture. The mode of disruption is remarkable. It constantly occurs in the interior of a segment, at the level of an inter-annular septum. The rupture also occurs in the longitudinally fibred muscles. Sometimes they only are broken, and the transversely fibred muscles above them simply show a depression. At the point of rupture the muscular fibres are disaggregated, and look like the ends of a cord broken by strong tension. The subcutaneous layer and skin are then parted, and their free ends contract, and cohere together by contact, so as to enclose the ruptured parts. After a while the parts necessary to the completion of each zooid are developed. The earth-worm acquires a head on the posterior half when bisected. Little is known as to whether annelids do or not multiply their segments throughout the whole of their existence, and whether they live one or many years. These latter points could easily be settled by some of our local naturalists' field clubs, who would direct the attention of members to the sedentary species.

The annelids are the counterparts of the *Lumbricidæ* and *Naides*. The former are marine; the latter are freshwater and terrestrial. In going from high-water mark seaward the *Aricea* appear first; then *Aphroditea*, *Nereidea*, *Arenicolea*, and *Eunicea*. The *Glycerea* and *Clymenea* occur in the lowest zones. Most annelids are mud and sand dwellers. They especially frequent the flats between high and low-water marks. One species, however, *Sabella saxicava*, is peculiar amongst its class for riddling galleries in hard limestones. The richest habitats are where sand and mud are mixed in the proper proportion, so as to give the material a certain solidity without being too tenacious to be readily penetrated by these creatures. The prairies of *Zostera* are rich fields; the phytophagous species delight to feed upon it, and those with carnivorous propensities follow after the plant-eaters in order to prey upon them. The slopes of certain rocks are also richly inhabited by certain species. A few forms, such as *Eunice gigantea*, *E. Rousseaui*, *Torrea vitrea*, and *Heteronereis*, are pelagic; but even these, it is believed, resort to the shores for the purposes of reproduction, since the fertile individuals are always found near low-water mark. It is probable that all the species make a partial migration seaward during cold weather, since they are rarely found in winter in the places where they most abound in summer. Direct observations are, however, required to ascertain whether the annelids have or have not the migratory habits suggested. The way in which the galleries are drilled in the sand is curious. It is done by puffing out the proboscis against the sand; by propelling into it the fluid from the general cavity of the body; the space formed is generally wider than the body, so that the creatures can readily advance to make another push. As the operation is repeated rapidly, the rate of progress is considerable. In many instances the gallery is temporary only; but some species consolidate their sides and make habitual use of them in passing from one point to another. It is not known how the *Sabella saxicava* bores its way through limestone; but the probability is that it is done by some mechanical operation, since, if a solvent were employed, the walls would be rough and corroded, whereas they are remarkable for their regularity of form and smoothness of surface. Mr. Ray Lankester, however, has pointed out that the *Polydora ciliata* of the English coast also bores its habitation. In this instance, the facts tend rather to support the chemical view, since the individuals always select calcareous rocks, neglecting those of a non-calcareous nature; and since specimens of the annelids give a decided acid reaction when placed on litmus paper. He adduces the smoothness of the galleries as a fact in favour of chemical action. There is no perceptible difference between the mud-frequenting and the boring individuals of *Polydora ciliata*; but it is suggested that future research may indicate that two species were confounded under this name. This paper elicited from Dr. McIntosh a reply, in which he shows that *Polydora ciliata* constructs its dwelling in non-calcareous rocks, and gives details respecting all the other British species of boring worms. Many species construct tubes, which are in general characteristic of the species or genera. Those of *Serpula* are not so distinctive, so that in this group they do not afford reliable diagnoses.

With respect to the geographical distribution we are not in a position to go into details; but it may be said that no sea is without its representative of every order, and, indeed, many of the larger genera are cosmopolitan in their range. At present it would seem that annelids do not present that localization of groups in definite areas which is so marked in other classes. Combined with this, however, we have a remarkable restriction in the range of the species, so that, according to Quatrefages, there are no species common to two continents, two hemispheres, or the two seas of the same continent. Sometimes there is a total change of species within a very short range. Thus, to cite one example, the annelids on the oceanic shores of France are specifically distinct from those which tenant the Mediterranean coast line. There are exceptions, but they are accounted for by currents having transferred stray specimens from one region to another. There is no relation between locality and degrees of organisation; and hence there is a general equality of organisation in annelids all over the globe. The nature of the habitat, however, has a marked influence; since calcareous coasts possess but few genera and species, while granitic or schistose shores abound in both.

We next enter upon the subject of classification. The most generally accepted arrangement has been that proposed by Grübe in 1851; but it is not unlikely that the arrangement recently put forth by Quatrefages will be adopted by many students of the group. The difference between the two plans appears at first sight to be much greater than it actually is. It is true that they are drawn up upon different principles, but in the main the results are not totally different. Indeed the relative position of the genera and families is much the same in Grübe as in Quatrefages. Nevertheless, there are differences, and some of these are highly important from a classificatory point of view. They mostly arise from the groups being estimated differently by the two authorities. The following is an outline of Grübe's arrangement.

I. APPENDICULATA POLYCHÆTA.

A. *Rapacia.*
  Aphroditea.
  Amphinomea.
  Nephthydea.
  Glycerea.
  Phyllodocea.
  Lycoridea.
  Amytidea.
  Eunicea.
  Ariciea.

B. *Limivora.*
  Syllidea.
  Chætopterea.
  Pherusea.
  Maldania.
  Opheliacea.
  Telethusa.
  Terebellacea.
  Hermellacea.
  Serpulacea.

II. GYMNOCOPA.
  Tomopteridea.
III. ONYCHOPHORA.
  Peripatea.
IV. OLIGOCHÆTA.
  Lumbricina. *Naidea.*

V. DISCOPHORA.
  Hirudinacea.
  Clepsinea.
  Branchiobdellea.
  Acanthobdellea.

In Quatrefages' system the class *Annelida* comprises the orders *Dorsibranchiata* and *Tubicola* only of Cuvier, and the orders *Polychæta* and *Gymnocopa* of Grübe. Quatrefages attaches great importance to the definition and limitation of families, as he considers them to be the key-note of all classifications. They are in the main nothing more than the genera of Linnæus more accurately defined. Especial care is taken to form a decided opinion as to which family a genus belongs, but in many cases the genera have not been sufficiently described, and these are set apart by themselves as being doubtfully placed. In the formation of orders and sub-orders he has been guided by the following considerations:—It is absolutely necessary to take *all* the characters into account, since the annelids present a surprising amount of variation. The Jussieuan system of classifying is considered to be better than the Cuvierian. Cuvier looked for his characters in the organs of the most important functions; and this required the assumption that every function is performed by a special organ, which is far from being the case amongst invertebrates. The Cuvierian plan answers well for vertebrates, but is inapplicable to the invertebrates. The annelids afford abundant evidence of this. Cuvier, for instance, attached the greatest importance to the respiratory organs; but there are whole groups without branchiæ which are evidently nearly allied to others which have them. Jussieu proceeded by way of observation, and he considered those characters most essential which spread over the largest specific area.

An annelid is essentially formed of repetitive segments, having feet armed with retractile and exsertile setæ. The most important characters, then, are the modifications of this general type. In one group we find annelids in which all the segments have a general resemblance. This forms his order *Erraticæ*. It comprises the *Errantes* of Milne-Edwards and the *Rapacia* of Grübe, with the addition of the *Chloræmea* and *Polyophthalmea* families. In the second group the segments are dissimilar, so that the body is marked out into distinct regions. This group constitutes the order *Sedentaria*. It corresponds to the *Tubicola* of Cuvier and the *Limivora* of Grübe. Quatrefages assigns to it some genera which are usually placed amongst the *Errantes*, and also the *Tomopteridea*.

Each order has its sub-orders. In most *Erraticæ* all the segments are similar, but in some there are two kinds of segments, and these are repeated two and two over the greater length of the body. The first form the *Erraticæ proper*, the second the *Erraticæ aberrantes*. In the *Sedentaria* there is a small group which do not have a distinct demarcation of the body into regions. These are the *Sedentariæ aberrantes*, while the others are the *Sedentariæ proper*.

In forming his families he has had regard to both internal and external characters; but in his table the latter only are indicated for the sake of convenience. The armature of the mouth; the absence or presence of branchiæ; the position and form of these; the absence or presence of certain cephalic and pedal appendages; the modifications in the form of such appendages, have all been employed, and their relative importance is indicated by the order in which they are mentioned. The *Erraticæ* proper is composed of 13 families. Of these, 1, viz., the *Polyophthalmea*, is quite exceptional in having a cephalic rotary organ of locomotion. The remaining 12 represent the essential characters of the sub-order. They are readily divided into 2 groups, based upon the character of the buccal armature. In the one group are the *Eunicea* and *Lumbrinerea*, in the other the remaining 10 families. In the first group the stomatogastric nervous system originates in the brain, while in the second it arises from the connective part of the ganglionic chain. The digestive apparatus also differs markedly in the two groups. The 10 families with the simple buccal armature form well-marked secondary groups. The *Glycerea* form one: in it the head seems to be a miniature repetition of the body in being composed of a great number of segments. Accompanying this are other interesting morphological peculiarities, such as distinct blood globules, branchiæ of peculiar structure, almost entire absence of inter-annular septa, &c. The other 9 families form 2 groups, characterised by the presence of branchiæ in the one, and their absence in the other. A parallel case occurs amongst the *Erraticæ* with complicated buccal apparatus. In these, however, the absence of branchiæ is an organic simplification coinciding with others acting on the vascular system; otherwise the general type remains unaltered. The *Lumbrinerea* are in fact degraded *Eunicea*. In the *Erraticæ* with simple buccal armature this is not the case. The *Nereidea* are not degraded *Nephthydea*, since the first is superior in some respects to the second, and in no respect inferior. Amongst the *Erraticæ* with complicated buccal armature, the branchiated family is the more highly organised; but amongst the *Erraticæ* with the simple buccal armature one at least of the non-branchiated families has the superiority. This is an example of what Quatrefages means by *corresponding terms*. The *Erraticæ* with complex buccal armature form a natural group, since the type remains the same, although it may be well developed in some and ill developed in other genera. In the branchiated group the form and position of the branchiæ vary, without being accompanied by other differences in other systems. But amongst the *Erraticæ* with simple buccal armature the slightest variation in the respiratory system is associated with the most important differences in almost every other system, even the nervous. The composition of the brain, the mode of distribution of the principal nerves are quite exceptional in *Nephthys*, which in other respects resembles the Nereids. The *Nerinea* have a double abdominal nervous chain, and in this respect resemble the most characteristic *Sedentaria*. The *Cirrhatulea*, on the other hand, have the abdominal ganglions fused into a single band, which reminds one of the same parts in *Clymene*. In short this group has characters which form the basis of many distinct secondary types. A similar heterogeneity is met with amongst the abranchiate division. The family *Syllidea* presents a striking example of degradation of structure with unity of type. It varies more, perhaps, than all the rest of the class, and it alone presents examples of some of the most interesting physiological phenomena, such as geneagenesis.

Of the 15 families comprising the order *Erraticæ*, 7 have, and 8 have not, branchiæ. The great majority both of families and species are abranchiate; and the genera, with the largest number of species, are abranchiate. *Polynoe*, with 77 species, and *Nereis*, with 81 species, being conspicuous examples. Of the 11 families of *Sedentariæ*, 8 have, and 3 have not, branchiæ. The latter consist of the *Chætopterea*, *Tomopterea*, and *Clymenea*, of which 2 are poor in species; while the genera most abundant in species occur in the branchiate group, such as *Terebella* and *Serpula*. In the two orders, the branchiæ are sometimes on the head, and sometimes on the body; but only one family (*Chloræmea*) amongst the *Erraticæ* has them on the head, while amongst the *Sedentariæ* the branchiæ are cephalic in most families. *Chloræmea* is, however, a true aberrant group. Quatrefages' reasons for thus differing from most previous authors as to the position of *Chloræmea* are these. This family unquestionably has some resemblance to the *Sedentariæ*, and it is also admissible that *Arenicolea*, *Opheliea*, and *Ariciea*, approach somewhat to the *Erraticæ*. But these resemblances are due to analogy, and not to affinity. The *Chloræmea* represent the Sedentarian type amongst the *Erraticæ*, and the *Opheliea* represent the *Erraticæ* amongst the *Sedentariæ*. There is a sort of reciprocity between the two orders.

Nereidea is one of the most natural families. It consists of the *Lycastis* and *Nereis* of old authors, which form a distinct group from the *Heteronereis* and *Nereilepas* added more recently. The law of repetition undergoes a change here. *Heteronereis* presents two well-marked regions, nevertheless it belongs to the *Erraticæ*, and not to *Sedentariæ*. The genus has the true Nereid structure, both internally and externally. The anterior feet resemble those of Nereids, even in the minutest details, and are adapted for walking. The posterior feet are modified so as to adapt them for swimming; but they nevertheless preserve the family form. They are precisely like the anterior feet, but are complicated by additional accessory parts. With this exception, all the segments are alike. So that the regional distinction depends upon superficial unimportant characters, and is not a reflex of the general typical form. The reciprocal of this occurs in *Terebellea* and *Serpulea*; the *Heteroserpulæ* and *Heteroterebellæ* are examples. The appearances result from pedal, not typical, modifications.

Corresponding terms are represented amongst the genera, as for instance in *Syllidea*, where group after group repeats the absence or presence of frontal lobes, the same number of antennæ, tentacles, eyes, &c. These groups are analogues, or the corresponding terms of each other. This feature is also well marked in *Nereidea*. *Reciprocal terms* are also present in families and tribes. Thus the *Sabellæ*, with calcareous tubes, form an exception to the general character of their type, and so far approach the *Serpula* type. Authors have accordingly placed *Protula* amongst the *Serpulea*, whereas the organization of its species plainly shows that the genus belongs to the *Sabella* type. Again, *Filograna* resembles the *Sabella* type in having no operculum, nevertheless it essentially belongs to the *Serpula* type. It will be noticed that similar characters are regarded as of dissimilar value in dissimilar groups. This is a prominent feature in Quatrefages' classification. The following are the tables above referred to :—

CLASS ANNELIDA.

(2 Orders; 4 Sub-orders; 26 Families.)

										Families.
ANNELIDA.	Regions of the body similar. ORDER I. ANNELIDÆ ERRATICÆ.	SUB-ORDER I.—ERRATICÆ ABERRANTES.								
		I. Segments similar.	With elytra							*Aphroditea.*
			No elytra							*Palmyrea.*
		SUB-ORDER II.—ERRATICÆ PROPRIÆ.								
		II. Segments dissimilar.	No rotary apparatus.	Buccal armature complex.	Branchiæ					*Eunicea.*
					No branchiæ					*Lumbrinerea.*
				Head of ordinary form.	True branchiæ.	Branchiæ somatic.	Arborescent			*Amphinomea.*
							Cirrhiform	Short	No true tentacles	*Nephthydea.*
									True tentacles	*Nerinea.*
								Elongated, filiform		*Cirratulea.*
						Branchiæ cephalic				*Chloræmea.*
					No true branchiæ.	Jaws, one pair; denticles				*Nereidea.*
						Jaws seldom present, sometimes denticles, never both.	Cirrhi simple.	Proboscis not exsertile		*Syllidea.*
								Pr. exsertile		*Hesionea.*
							Cirrhi lamellar			*Phyllodocea.*
				Head conical, composed of distinct segments						*Glycerea.*
			A rotary apparatus							*Polyophthalmea.*
	ORDER II. ANNELIDÆ SEDENTARIÆ.	SUB-ORDER III.—SEDENTARIÆ ABERRANTES.								
		Segments of one or more regions very dissimilar to each other								*Chætopterea.*
		SUB-ORDER IV.—SEDENTARIÆ PROPRIÆ.								
		Segments of one or more regions always similar or subsimilar to each other.	No branchiæ.	No setæ on feet						*Tomopteridea.*
				Setæ on all, or almost all, the feet						*Clymenea.*
			Branchiæ.	Somatic branchiæ.	Thoracic and abdominal, or only abdominal.	Arborescent				*Arenicolea.*
						Cirrhiform or laciniate.	No prehensile cirrhi. No tentacles.	Rami indistinct		*Opheliea.*
								Rami distinct		*Ariciea.*
							Tentacles			*Leucodorea.*
							Prehensile cirrhi			*Hermellea.*
					Thoracic exclusively	Operculum formed of setæ				*Pectinarea.*
						No operculum				*Terebellea.*
				Cephalic branchiæ						*Serpulea.*

Family I. APHRODITEA (15 genera).

I. Elytra dorsal.
A. Elytra confined to some of the feet.
a. No dorsal cirrhi . . . . 1. *Pholoë.*
b. Dorsal cirrhi.
* Dorsal cirrhi alternating with the elytra.
α. Jaws none, or rudimentary.
a. Hairs on the feet . 2. *Aphrodite.*
b. No hairs on the feet.
** 3 antennæ . . 3. *Hermione.*
†† 2 antennæ . . 4. *Milnesia.*
β. Jaws corneous . . 5. *Polyodontes.*
a. 4 antennæ.
b. 3 antennæ.
** Pseudobranchial tubercles . . . 6. *Acoëtes.*
(1) Elytra all along the body . 7. *Polynoë.*
(2) Elytra leaving the posterior part of the body uncovered . 8. *Lepidonotus.*
c. 2 antennæ . . . . 9. *Iphione.*
† Dorsal cirrhi on all the feet.
α. Elytra covering the whole body.
a. 3 antennæ . . . 10. *Sthenelaïs.*
b. 2 antennæ . . . 11. *Sigalion.*
c. 1 antenna . . . 12. *Psammolyce.*
β. Elytra leaving the posterior part uncovered . 13. *Hemilepidia.*
B. Dorsal elytra on all the feet . 14. *Pelogenia.*
II. Elytra dorsal and abdominal . . 15. *Gastrolepidia.*
Genera *incertæ sedis* 2 : *Hermenia; Eumolphe.*

Family II. PALMYREA (4 genera).

I. Segments not numerous.
A. Feet biramose.
a. 1 antenna . . . . . 1. *Palmyra.*
b. 3 antennæ . . . . . 2. *Chrysopetalon.*
B. Feet uniramose . . . . 3. *Paleanotus.*
II. Segments numerous . . . . 4. *Bhawania.*

Family III. EUNICEA (4 genera).

I. Antennæ 5.
A. Tentacles . . . . . . 1. *Eunice.*
B. No tentacles . . . . . 2. *Marphysa.*
II. Antennæ 7.
A. Tentacles . . . . . . 3. *Diopatra.*
B. No tentacles . . . . . 4. *Onuphis.*

Family IV. LUMBRINEREA (8 genera).

I. Antennæ wanting.
A. No dorsal cirrhus . . . 1. *Lumbrinereïs.*
B. With a dorsal cirrhus . . 2. *Notocirrus.*
II. Antenna single.
A. No dorsal cirrhus . . . 3. *Blainvillea.*
B. With a dorsal cirrhus . . 4. *Nematonereïs.*
III. Antennæ 2 . . . . 5. *Oenone.*
IV. Antennæ 3.
A. Head free . . . . . 6. *Lysidice.*
B. Head concealed . . . . 7. *Aglaura.*
V. Antennæ 5 . . . . 8. *Plioceras.*
Genus *incertæ sedis: Zygolobus.*

Family V. AMPHINOMEA (7 genera).

I. Feet biramose.
A. With antennæ and tentacles.
a. Branchiæ pinnatifid . . 1. *Chloë.*
b. Branchiæ arborescent . . 2. *Amphinome.*
c. Branchiæ cirrhiform . . 3. *Linophera.*
B. With one antenna . . . 4. *Euphrosyne.*
II. Feet uniramose.
A. With antennæ and tentacles . 5. *Hipponoë.*
B. Antennæ and tentacles wanting.
a. Branchiæ in rows . . 6. *Lophonota.*
b. Branchiæ in groups . . 7. *Didymobranchus.*
Genera *incertæ sedis* 2 : *Aristenia; Cryptonotus.*

Family VI. NEPHTHYDEA (3 genera).

I. Head bearing antennæ.
A. Antennæ 4 . . . . . . 1. *Nephthys.*
B. Antennæ 2 . . . . . . 2. *Portelia.*
II. Antennæ wanting . . . . . 3. *Diplobranchus.*

Family VII. NERINEA (6 genera).

I. Feet biramose.
A. Feet without cirrhi.
a. No uncini . . . . . . 1. *Nerine.*
b. Uncini present . . . . 2. *Uncinia.*
B. Feet bearing cirrhi.
a. Inferior cirrhi only . . . 3. *Aonis.*
b. Inferior and superior cirrhi.
* No eyes . . . . . 4. *Malacocera.*
† Eyes present . . . . . 5. *Colobranchus.*
II. Feet uniramose . . . . . 6. *Pygospio.*
Genera *incertæ sedis* 2 : *Pygophyllum; Clytia.*

Family VIII. CIRRATULEA (6 genera).

I. Branchiæ on nearly all the segments.
A. Branchiæ both pedal and dorsal.
a. The two sorts of branchiæ appearing at the same time . 1. *Cirratulus.*
b. Pedal branchiæ preceding the dorsal . . . . . . 2. *Audouinia.*
B. Pedal branchiæ only . . . 3. *Cirrinereïs.*
II. Branchiæ on the anterior segments only.
A. No tentacles . . . . . . 4. *Dodecaceræa.*
B. One pair of tentacles . . . 5. *Heterocirrus.*
C. Three pairs of tentacles . . . 6. *Nagaranseta.*

Family IX. CHLORÆMEA (5 genera).

I. Body covered with hairs . . . . 1. *Chloræma.*
II. Body without hairs, or with very short hairs.
A. Head protected by setæ.
a. All the feet biramose.
* Head very distinct . . . 2. *Siphostomum.*
† Head indistinct . . . . 3. *Pherusa.*
b. Only the fore-feet biramose . 4. *Lophiocephala.*
B. Head entirely uncovered . . . 5. *Brada.*
Genera *incertæ sedis* 4 : *Spinther; Flemingia; Stylaroides; Tecturella.*

Family X. NEREIDEA (4 genera.)

I. Body forming one region.
A. Feet uniramose . . . . . 1. *Lycastis.*
B. Feet biramose . . . . . . 2. *Nereïs.*
II. Body forming two regions.
A. All the setæ like those of *Nereïs* . 3. *Nereïlepas.*
B. Part or the whole of the setæ remiform . . . . 4. *Heteronereïs.*
Genera *incertæ sedis* 2 : *Micronereïs; Zothea.*

Family XI. SYLLIDEA (31 genera).

I. Feet moveable.
A. With dorsal and abdominal cirrhi.
a. No tubercles on the body.
* Gizzard armed.
. 4 antennæ.
a. 12 tentacles . . . 1. *Syllidia.*
b. No tentacles . . . 2. *Prionognathus.*
β. 3 antennæ . . . . 3. *Gnathosyllis.*
** Gizzard unarmed.
α. Head and buccal segment distinct.
a. With frontal lobes.
† Antennæ 5 . . 4. *Pterosyllis.*
†† Antennæ 4 . . . 5. *Brania.*
††† Antennæ 3.
1. Tentacles 8 . . 6. *Procoma.*
2. Tentacles 4.
Eyes 4 . . . 7. *Syllis.*
Eyes 6 . . 8. *Ehlersia.*
3. Tentacles 0 . . 9. *Exogone.*
†††† Antennæ 2 . . 10. *Grubea.*
b. No frontal lobes.
† Antennæ 4.
1. Tentacles 16 . . 11. *Kefersteinia.*
2. Tentacles 0 . . 12. *Eucerastes.*
†† Antennæ 3.

1. Tentacles 4.	
Eyes 4	13. *Autolytus.*
Eyes 0	14. *Trichosyllis.*
2. Tentacles 2	15. *Heterosyllis.*
3. Tentacles 0	16. *Gossia.*
β. Head and buccal segment confounded.	
a. With frontal lobes.	
† 3 antennæ and 4 tentacles determinable	17. *Claparedia.*
†† Antennæ and tentacles indeterminable 8.	18. *Cystonereïs.*
5.	19. *Sphærosyllis.*
4.	20. *Oophylax.*
3.	21. *Isosyllis.*
b. No frontal lobes : antennæ and tentacles indeterminable 7.	22. *Thylaciphora.*
5.	23. *Ambliosyllis.*
0.	24. *Tetraglena.*
b. With tubercles on the body	25. *Euryosyllis.*
B. No abdominal cirrhi.	
a. With frontal lobes	26. *Sylline.*
b. No frontal lobes.	
* Antennæ 3.	
α. Tentacles 4	27. *Myrianida.*
β. Tentacles 2	28. *Ioida.*
† Antennæ 2	29. *Microsyllis.*
C. Neither dorsal nor abdominal cirrhi	30. *Schmardia.*
II. Feet immoveable	31. *Dujardinia.*

Genera *incertæ sedis* 17 : *Polybostrichus* ; *Sacconereïs* ; *Polynice* ; *Diplocerœa* ; *Photocharis* ; *Macrochæta* ; *Syllia* ; *Crithida* ; *Anisoceras* ; *Staurocephalus* ; *Sigambra* ; *Diplotis* ; *Ephesia* ; *Sphærodorum* ; *Pollicita* ; *Aporosyllis* ; *Cirroceros.*

Family XII. Hesionea (10 genera).

I. Feet uniramose.	
A. Size comparatively large.	
a. Segments very numerous	1. *Myriana.*
b. Segments few.	
* Antennæ 4	2. *Hesione.*
† Antennæ 2	3. *Fallacia.*
B. Size small.	
a. Antennæ 4.	
* Tentacles 14	4. *Periboëa.*
† Tentacles 8	5. *Psamathe.*
‡ Tentacles 6	6. *Lopadorhynchus.*
b. Antennæ 5.	
* Tentacles 12	7. *Podarka.*
† Tentacles 10	8. *Mania.*
II. Feet biramose.	
A. Antennæ 8	9. *Pseudosyllis.*
B. Antennæ 4	10. *Castalia.*

Genera *incertæ sedis* 5 : *Pisione* ; *Oxydromus* ; *Halimede* ; *Cirrosyllis* ; *Orseïs.*

Family XIII. Phyllodocea (12 genera).

I. Eyes of ordinary size.	
A. Feet uniramose.	
a. Antennæ 5.	
* Tentacles 10	1. *Kinbergia.*
† Tentacles 8	2. *Eulalia.*
‡ Tentacles 6	3. *Eracia.*
b. Antennæ 4.	
* Tentacles 8	4. *Phyllodoce.*
† Tentacles 6	5. *Carobia.*
‡ Tentacles 4	6. *Eteone.*
§ Tentacles 2	7. *Lugia.*
c. Antennæ 2	8. *Macrophyllum.*
B. Feet biramose	9. *Notophyllum.*
II. Eyes very large.	
A. Feet bearing two glandular organs	10. *Alciope.*
C. Feet with a single glandular organ.	
a. Antennæ 5.	11. *Krohnia.*
b. Antennæ 0	12. *Torrea.*

Genera *incertæ sedis* 2 ; *Eumenia* ; *Liocape.*

Family XIV. Glycerea (3 genera).

I. Feet biramose.	
A. Rami approximate	1. *Glycera.*
B. Rami distant	2. *Goniada.*
II. Feet uniramose	3. *Hemipoda.*

Genera *incertæ sedis* 2 : *Glycinde* ; *Proboscidia.*

Family XV. Polyophthalmea (1 genus, viz., *Polyophthalmus*).

Family XVI. Chætopterea (1 genus, *Chætopterus*).

Genus *incertæ sedis* : *Spiochætopterus.*

Family XVII. Tomopteridea (1 genus, *Tomopteris*).

Family XVIII. Clymenea (10 genera).

I. Body in three regions.	
A. With an anal funnel.	
a. No respiratory cæca.	
* Cephalic plate developed	1. *Clymene.*
† Cephalic plate none, or rudimentary	2. *Leiocephalus.*
b. Respiratory cæca present	3. *Johnstonia.*
B. With an anal plate.	
a. With a cephalic plate	4. *Maldane.*
b. No cephalic plate	5. *Petaloproctus.*
C. Neither plate nor funnel	6. *Ammochares.*
II. Body in two regions.	
A. Head truncate	7. *Clymenidia.*
B. Head not truncate.	
a. Head acute.	
* Posterior region with simple setæ	8. *Arenia.*
† Posterior region with uncini only	9. *Ancistria.*
b. Head club-shaped	10. *Clymenia.*

Genera *incertæ sedis* 3 : *Capitella* ; *Notomastus* ; *Dasybranchus.*

Family XIX. Arenicolea (2 genera).

I. Branchiferous feet consecutive	1. *Arenicola.*
II. Branchiferous feet separated by abranchiate ones	2. *Chorizobranchus.*

Genera *incertæ sedis* 2 : *Scalibregma* ; *Polyphysia.*

Family XX. Opheliea (3 genera).

I. Feet with a single branchia.	
A. On the middle region	1. *Ophelia.*
B. Nearly on the whole body.	2. *Travisia.*
II. Feet with several branchiæ	3. *Branchoscolex.*

Genera *incertæ sedis* 3 : *Ophelina* ; *Ammotrypane* ; *Sclerocheilus.*

Family XXI. Aricіea (5 genera).

I. Proboscis of ordinary form.	
A. Lower ramus of anterior feet bearing uncini.	
a. No antennæ	1. *Aricia.*
b. With antennæ	2. *Orbinia.*
B. Lower ramus of anterior feet with simple setæ.	
a. No caruncle	3. *Scoloplos.*
b. Caruncle present.	4. *Porcia.*
II. Proboscis divided into foliaceous lobes	5. *Anthostomum.*

Genera *incertæ sedis* 4 : *Magelona* ; *Gisela* ; *Theodisca* ; *Hermandura.*

Family XXII. Leucodorea (5 genera).

I. Feet different.	
A. Feet biramose.	
a. Branchiæ superior	1. *Leucodore.*
b. Branchiæ inferior	
* Third segment abnormal	2. *Disoma.*
† Fifth segment abnormal	3. *Polydora.*
B. Feet uniramose	4. *Spione.*
II. Feet similar	5. *Spiophanes.*

Genus *incertæ sedis* : *Spio.*

Family XXIII. Hermellea (3 genera).

I. Body in 3 regions.	
A. Operculum with 3 rows of setæ	1. *Hermella.*
B. Operculum with 2 rows of setæ	2. *Pallasia.*
II. Body in 2 regions	3. *Centrocorone.*

Genera *incertæ sedis* 2 : *Branchiosabella* ; *Uncinocheta.*

Family XXIV. Pectinarea (2 genera).

I. Branchiæ 2 pairs	1. *Pectinaria.*
II. Branchiæ 3 pairs	2. *Scalis.*

Family XXV. Terebellea (11 genera).

I. Body in 2 regions.

A. With dorsal branchiæ.

a. Dorsal branchiæ arborescent { 3 pairs 1. *Terebella.*
2 pairs 2. *Physelia.*
1 pair 3. *Idalia.*
b. Dorsal branchiæ pectinated, median. . . . . 4. *Terebellides.*
c. Dorsal branchiæ cirrhiform.
* Buccal cirrhi simple . . 5. *Phenacia.*
† Buccal cirrhi pinnate . 6. *Sabellides.*
d. Dorsal branchiæ cirrhiform and pinnate . . . . . . 7. *Isolda.*
B. No dorsal branchiæ . . . . 8. *Apneumea.*
II. Body in one region.
A. dorsal branchiæ arborescent { 3 pairs . 9. *Heteroterebella.*
2 pairs . 10. *Heterophyselia.*
B. Branchiæ cirrhiform . . . 11. *Heterophenacia.*
Genera *incertæ sedis* 7 : *Rhytocephalus* ; *Amphicteïs* ; *Polycirrus* ; *Sabellina* ; *Anisomelas* ; *Piratesa* ; *Lumara.*

Family XXVI. SERPULEA (21 genera).

I. Head without an operculum.
A. Regions distinct.
a. Tube membranous.
* Branchiæ with a circular base.
α. Cirrhi free.
a. No caudal eyes . . 1. *Sabella.*
b. Caudal eyes.
1. Antennæ present.
With a collar . . 2. *Oria.*
Without a collar . 3. *Amphiglena.*
2. No antennæ . . 4. *Fabricia.*
β. Branchial cirri united . 5. *Chonea.*
† Branchiæ with a spiral base.
α. A single branchia in spiral . . . 6. *Spirographa.*
β. Both branchiæ in spiral 7. *Distylia.*
b. Tube calcareous.
* Branchiæ with a spiral base 8. *Protula.*
† Branchiæ with a circular base . . . . . 9. *Psygmobranchus.*
B. Regions indistinct.
a. With feet.
* Branchial cirrhi free.
α. With barbules . . . 10. *Anambœa.*
β. No barbules . . 11. *Amphicorine.*
† Branchial cirrhi united . . 12. *Myxicola.*
b. Without feet.
* Branchiæ with barbules . 13. *Gymnosoma.*
† Branchiæ without barbules . 14. *Phoronis.*
II. Head with an operculum.
A. Two or more false opercula . . 15. *Filograna.*
B. With true opercula.
a. Tube completely rolled up . 16. *Spirorbis.*
b. Tube more or less sinuous.
* Two symmetrical opercula . 17. *Codonytes.*
† One operculum.
α. Tube free . . . 18. *Ditrupa.*
β. Tube attached.
a. Branchiæ with circular base.
1. Operculum corneous 19. *Serpula.*
2. Operculum corneo-calcareous . . 20. *Vermilia.*
b. Branchiæ with a spiral base . . . 21. *Cymospira.*
Genera *incertæ sedis* 5 : *Spiramella* ; *Apomatus* ; *Spiroglypha* ; *Stoa* ; *Vermiculum.*

ANODON or ANODONTA [NAIADÆ, E. C. vol. iii. cols. 1048—1055], a genus belonging to the family of river mussels, or *Unionidæ*, and differing but little, either in the soft or the hard parts, from *Unio.* The body and shell are of a long oval shape; the gills are flexuous, and the labial palps are lanceolate. The shell is thin, smooth, and somewhat ventricose in old individuals: the teeth on the hinge line are rudimentary, and the lunule is slight and indistinct. According to Bronn, 8 tertiary species were known in Europe in 1860, and 100 living species, the majority of which (60) occur in North America; while 1 only is recorded from Northern Europe, and 1 from Southern Europe. The other species are distributed through the tropical and northern parts of America and Asia. It may well be questioned whether all these forms are entitled to specific rank; for it is exceedingly difficult to discriminate the species in this genus. Jeffreys regards the North European forms as belonging to two species, viz., *A. cygnea*, and *A. anatina*, both of which occur in England, but the former only extends into Ireland and Scotland. Their habits much resemble those of the species of *Unio*, and both are to be found in most of the sluggish flowing rivers and canals, as well as the lakes, canals, and ponds throughout the area of their distribution. *A. cygnea* ranges from Siberia to the Pyrenees, and occurs in the upper tertiary strata of England; and *A. anatina* extends as far south as Sicily, but has not yet been recorded in the English tertiaries. The principal differences between these two species consist in the latter having a smaller but proportionally longer shell, in having a raised, not flat, hinge line, and in the posterior side sloping away abruptly, and not gradually, as in *A. cygnea.* Five or six species occur in Algeria, all of which are distinct from those of Europe. As bearing upon the possible migration of this genus into England from the south and east parts of Europe, it is an interesting fact that a species closely allied to *A. cygnea* has been recently found in the lower Oligocene shales at Roth, on the Rhone. It has been named *A. prædemissa* by Ludwig. It was somewhat larger than *A. cygnea;* the average specimens of the latter are about 2·75 inches long and 5·35 broad; while the extinct form measured 3·1 inches in length, and 5·8 in breadth. There are some doubts as to the occurrence of this genus in the Palæozoic rocks; but one species, viz., *A. Jukesii*, has been recorded from the upper Old Red Sandtone, and several species from the Carboniferous and Permian strata of Russia and Germany. It is noticeable that amongst these Palæozoic forms, those from the more southern localities are smaller than those found in higher latitudes: in other words, the Russian species are smaller than the German.

ANOMŒPUS. [BIRDS, E. C. S.]

ANORTHITE is a mineral belonging to the Felspar family, and having a composition closely resembling that of Scapolite. It differs from it in containing magnesia, potash, soda, and oxide of iron amongst its ingredients, which have replaced a small portion of the lime. It has many of the physical properties of Scapolite, but is somewhat harder than it, ranking from 6 to 7 in the scale of hardness. It includes many varieties, amongst others Amphodelite, Bytownite, Diploite, or Latrobite, Indianite, Lepolite, Lindsayite, Polyargite, Rosellan, Sundvilkite, and Wilsomite. It has been found in hornblende, syenite, and the greenstone dykes, traversing the limestone of Carlingford Mountain in Ireland; in cavities in the old lavas of Monte Somma; in the Faroë Islands, Java, and the Ural Mountains.

ANORTHOSITE is the name given to a group of rocks which consist almost entirely of a Felspar containing soda and lime, and whose cleavage planes are not at right angles to one another. They are developed in remarkable abundance in Canada, where they constitute strata many thousand feet thick. They predominate more especially in the Upper Laurentian Series of rocks, and contrast with the rocks forming the Lower Laurentian Series [LAURENTIAN ROCKS, E. C. S.] Foreign minerals are few and far from abundant. Carbonate of lime occurs in small quantities: quartz is exceedingly rare; garnets sometimes occur in lines which mark the planes of stratification; a brownish-black mica is met with in some of the granitoid varieties; hypersthene is characteristic of some varieties; while grains and lenticular masses of ilmenite are in places associated with a green augite in thin interrupted parallel layers. Selecting ten specimens of felspar as representing the average composition of these rocks, we find that they contained:—

Silica	56·
Alumina	27·30
Lime	9·42
Soda	4·84
Potash	·84
Peroxide of iron, and volatile matters	1·60

The most noticeable features are the comparative abundance of lime and soda, and insignificant proportions of potash and peroxide of iron. The large quantity of lime in these old rocks is an important fact, since it has been surmised by some palæontologists that the rarity of the remains of *Mollusca* with calcareous shells, and the predominance of *Lingulæ*, in whose shells carbonate of lime is an unimportant ingredient, in the oldest fossiliferous strata of most countries, is connected with the small quantity of lime which appears to have been present in the seas of the period. This subject is referred to more particularly elsewhere. Anorthosites occur amid some of the Silurian strata, but nowhere are they in such force as in the North American area of the Laurentian Series.

(Sir W. Logan, *Geology of Canada*, 1863.)

ANTHRACONITE, a name given to the black limestones, especially those which emit a fetid odour when rubbed [MARBLE, E.C.]

ANTHROPOLITES [E. C. vol. i. col. 231]. Few subjects have been more voluminously discussed of late years than that of the antiquity of man. The evidence bearing upon it is derived partly from the position of human bones in caves and recent strata; but in a still greater degree from other phenomena. Amongst them may be mentioned the association of his handiwork with the bones of animals which have long since become extinct; the present variety in the anatomical structure; and the material characteristics and geographical distribution of the numerous races of mankind. It is from a consideration of the rate with which modifications of structure occur: languages grow, flourish and decay; peoples and nations spread themselves over continents, emerge from barbarism, acquire an individualised character, develope civilisation, and vanish into obscurity, as compared with the present state of mankind, that an estimate is formed of the antiquity of man. The subject is far too wide and extensive to be discussed here, and therefore, the reader is referred for supplementary details respecting fossil human remains to MAN, E. C. S.

ANTHUS [E. C. vol. i. col. 231, 232]. This genus, which is nearly allied to the Larks, agrees with *Alauda*, in having species which range right across the European and Asiatic continents, which species, like those of the lark-group, undergo varietal modifications in different geographical areas. Of the five British species mentioned in the E. C. article, probably three are to be met with in the far East. It is only within the last few years that Rock Pipits have been recorded from China, and in most instances they have received separate specific names.

A. agilis, Sykes, was first observed in India. It winters in the south of China, and during the summer migrates north into the northern parts of the same country, especially the Amoor-land, and to Japan. It closely resembles *A. arboreus*, and is probably a variety of that species.

A. Blakistoni, Swinhoe. This species is founded on a specimen captured on the great Chinese river Yang-tse. It is scarcely to be distinguished from *A. obscurus*. The describer says of it, "This rather closely tallies with one in Mr. Gould's collection from Ireland; but ours has a whiter face and cheek, and the pectoral spots, which blend away obscurely in the Irish skin, are in ours distinct and well marked." And further on he admits it may be only a well-marked race, to which the British form may be found occasionally to assimilate. The difference between these two specimens from the most distant parts of the same great continent, from localities indeed which are thousands of miles apart, is less than may be detected in the Dusky Pipits of Ireland alone. It is extremely probable that when a series of specimens from China and the west of Europe are compared together, they will be found to be specifically identical. At any rate, a species founded upon such trivial differences, derived from the comparison of two individuals only, can only be regarded as provisional. This species is probably identical with the *Anthus aquaticus* observed by Von Schrenck in Kamtchatka, and by Schlegel in Japan.

A. Richardi. This is recorded as a Chinese bird by Swinhoe, under the name of *Corydalla Richardi*, Vieillot, who has the following interesting remarks on it:—"I have a very large number of this species, shot at Amoy and elsewhere in China, Siam, and India. It is in South China a winter bird, but a few remain about the hills to breed. I found a few on the Foochow hills in June; these were smaller, with large bills and eyes, and darker and more distinctly marked plumage. I sent one to Mr. Blyth, who, under the impression that it came from the Philippines, christened it under the new name *C. infuscata*. But between this and the ordinary winter race I have every gradation of form and plumage. I also procured in spring, at Amoy, a few specimens of a somewhat smaller pipit, richly washed with ochreous; this is Bonaparte's species *C. sinensis*, and if correctly identified by Mr. G. R. Gray, *Anthus thermophilus*, Hodgson. But here again, in my large series, every step both in form and colour occurs between it and the larger paler race. It is easy to conjecture how these different climatic races of the same bird should turn up at one spot. For the island of Amoy by its position affords a resting place to vast numbers of birds bound on widely different migrations; and the different groups of the Richard's Pipit, influenced in their forms and tints by the greater or lesser heat of their birth-places and summer resorts, and doubtless by other local circumstances, in passing to their winter quarters rest for a few days on our island. The large pale variety stays the cold weather with us; the rich-tinted variety arrives early, passes away, and returns late, thence showing that it has a long way to travel southwards. The intermediate forms are less regular in their movements. As the nesting area is found to be more fixed than their winter haunts, the same birds returning to breed year after year to the same spot, it is not improbable that the extreme forms of these races would be found to inhabit in summer areas widely divided, the intermediate gaps being filled up with forms intermediate and approximating most nearly to those to which they were nearest, until amalgamation would arrive." (*Proc. Zool. Soc.* 1863, p. 272.)

ANTIQUITY OF MAN. [MAN, E. C. S.]

APHIS [E. C. vol. i. cols. 273—275]. The marvellous fecundity of the *Aphis*, together with the circumstances under which it is developed, affords to the naturalist facts of the highest interest, and opens up questions the solution of which lies at the very root of the true explanation of that power, or combination of powers, by which like produces its like in the organic world. In the higher animals the influence of the males precedes the development of every individual; but in the *Aphis* and many of the lower animals the same influence appears to suffice for the development of many thousands, probably millions, and, if we accept the calculations made by Morren and adopted by Professor Owen, more than a quintillion of individualised forms. The difference is so striking, that we will state it roughly in another way. A human ovum weighs, we will suppose, 100 grains, which is very much under the mark; by contact with a certain number of cells of a special character, which need not weigh in the aggregate more than a few grains, certain changes are superinduced by which the substance of the egg is developed into tissues, the tissues organised, and the principle of life imparted to them. The cells of the embryo multiply and increase until they ultimately form an individual, whose weight rarely exceeds two million grains. On the other hand the ovum of the *Aphis* weighing, we will say, a few grains, is fecundated by sperm cells less than a grain in weight, and the cells of this ovum subsequently so multiply that they will give rise to an amount of organised tissue which would outweigh 500 million of men, or half the population of the globe. The general opinion seems to be, that all these changes are brought about by some force concentrated in the sperm cells, and this is in the main the opinion of Morren and Professor Owen. The latter authority, for example, has expressed his belief that what he terms spermatic force (which we take to be some force actually resident in certain sperm cells which weighed but a few grains) is transmitted to a mass of germ cells, and that these germ cells are the direct excitants of all the changes in the successive generation of cells until the impregnation of the next ovum. Hence it is evident that on such a supposition the original stock of force will be exhausted sooner or later. In order to guard against misinterpretation, we will quote a few of the sentences in which the Professor enunciates these opinions. "It would be needless to multiply the illustrations of the essential condition of these phenomena. That condition is, the retention of certain of the progeny of the primary impregnated germ cell, or in other words, of the germ mass unchanged in the body of the first individual developed from that germ mass, with so much of the spermatic force inherited by the retained germ cells from the parent cell or germ-vesicle as suffices to set on foot and maintain the same series of formative actions as those which constituted the individual containing them. . . . The physiologist congratulates himself with justice when he has been able to pass from cause to cause, until he arrives at the union of the spermatozoon with the germinal vesicle as the essential condition of development—a cause ready to operate when favourable circumstances concur, and without which cause these circumstances would have no effect. What I have endeavoured to do has been to point out the conditions which bring about the presence of the same essential cause in the cases of the development of an embryo from a parent that has not itself been impregnated. The cause is the same in kind though not in degree, and every successive generation or series of spontaneous fissions of the primary impregnated germ cell, must weaken the spermatic force transmitted to such successive generation of cells. The force is exhausted in proportion to the complexity and living powers of the organism developed from the primary germ cell and germ mass." ('Lectures on the Comparative Anatomy of the *Invertebrata*'). Professor Owen's explanation seems to us to leave the matter much as it was before, since the assigned cause is clearly inadequate to produce the subsequent phenomenon. No doubt the union of sperm and germ cells precedes development, but no physicist can conceive that the quantity of force associated with a few grains of matter will suffice for the movement of a mass many tons in weight. All that the facts seem to show is that there is a power of some sort in the sperm and germ cells which commences a series of changes, but there is nothing to warrant the inference that the force by which these changes are effected is derived from the sperm cells. This sort of action reminds us strongly of what the chemist calls *catalysis*. The fallacy in both these cases, we think, has been happily put by Professor Huxley, when he suggests that a bullet is propelled by 'trigger force.' In the case of the bullet we know that the mere force with which we pull the trigger is not that which propels the projectile. The real force is derived from the gunpowder, but it would require too much space to explain here how it is the force is so easily liberated. But the main feature of all these actions may be illustrated by a simpler case. A man draws the string of a cross-bow, and places an arrow in a position to be fired. Another man comes forward and with a slight touch of his finger releases the string, and the result is that the arrow is propelled some hundreds of yards. Here then a man by an exertion of strength establishes an inequilibrium of forces; and a second by a little finger force restores the equilibrium. But the force which is thereby released is not finger force, but was derived from the muscles of another individual. We believe the development of animals to be a parallel case; the matter is so arranged beforehand, that a slight initial force will bring about a long concatenation of results. The extent of change that is brought about will not depend upon the amount of trigger force, but upon the quantity and proper disposition of the gunpowder and bullet: nor upon the amount of spermatic force, but upon the quantity and disposition of the matter which it acts upon.

So much by way of introduction. We will now endeavour to ascertain what is the nature of the agamic reproduction of the *Aphis*. In the autumn the impregnated females, which never possess wings (although many respectable authorities have asserted the contrary), lay eggs. These remain dormant throughout the winter, and in early spring they give rise to broods which may or may not have wings. These never lay eggs, they do not possess sexual organs, and they produce their young viviparously. Viviparous broods succeed each other one after another so long as food is plentiful and the weather is warm. In this country the changes of seasons do not usually permit more than nine or ten successive broods; but if the tenth brood be placed under favourable circumstances, viviparous generation may be continued for, so far as we yet know, an indefinite length of time. For instance, Kyber kept up viviparous generation for four years, when agamic reproduction seemed to be as active as at any previous period. However, under natural circumstances, the agamic mode of reproduction is brought to a stop by the scarcity of food and the accession of cold; sexual individuals then appear, and eggs are again laid. The recurrence of fertilisation, and the deposition of eggs, seem to be a periodical phenomenon dependent rather upon the seasons than upon physiological causes only.

One of the questions which here suggests itself is, whether any differences can be detected between the development of the embryo formed in the body of its parent, and of that which is derived from a deposited egg. In the viviparous female, the reproductive organs consist of a series of long blind canals, constricted here and there, so as to form a series of chambers. In the most anterior chamber, or that which is nearest the blind end of the canal, certain vesicles separate from the wall of the chamber by a process which may be compared to simple fission. Each vesicle becomes surrounded by a homogeneous, granular envelope. So far as mere appearances are concerned, these bodies are undistinguishable from ova in their earliest stages. Hence, for the sake of distinction, Professor Huxley calls them pseudova. The pseudova pass backward in the pseudovarian canal, and at the same time undergo changes, the most important of which is the disappearance of the vesicles, and their conversion into germ-masses composed of nucleated cells, surrounded by a granular envelope. In this stage the central part resembles the vitellus of an ordinary egg, while the enveloping part resembles the blastoderm. As development proceeds, the blastoderm thickens, more especially on the posterior side of the germ; the thickened portion becomes marked off by a depressed line, and the whole becomes inclosed in a thin structureless membrane. At a still further stage, rudiments of the head, thorax, and abdomen make their appearance, and still later a series of canals representing the pseudovarian canals appears in the central part, from which is also developed the alimentary canal. In the peripheral portion of the germ the limbs, muscles, and nerves take their origin, and before the embryo is discharged into the air, it has acquired all the organs that will enable it to maintain its own existence independently.

In the oviparous female, the oviduct consists of four ovarian cæca, each of which is divided into a series of chambers by constrictions. In the apical chamber there is a group of bodies whose formation appears to be of a secretory nature. It would seem that the germinal vesicles originate from the epithelium lining the apical chamber, by simple separation. As these pass backward, they are enveloped in a zone of clear substance which represents the future yolk, and is apparently derived from the glandular bodies above mentioned. When fully formed, the ovum is of an oval form, and of a dark green colour. It is covered by a tough transparent membrane, or the chorion; beneath this is the vitelline membrane, which immediately invests the yolk. The egg is laid, and undergoes the same or similar changes as the pseudovum, the embryo is developed in the same way, and the *Aphis* derived from an ovum is in no respect different from the *Aphis* derived from a pseudovum. The starting point is similar in both ovum and pseudovum, and the ultimate product is the same, but different roads are taken in order to arrive at the final result.

Such are the main facts; and in order to show what conclusions they seem to lead to, we will quote those suggested by Professor Huxley. After having drawn up certain propositions based upon the facts mentioned by him, he says, "If these propositions are correct, I see no valid objection to the conclusion, that the agamic offspring of *Aphis* is developed from a body of precisely the same character as that which gives rise to the true egg. The pseudovum is detached from the pseudovarium in the same way as the ovum from the ovarium. In both cases the act of separation is in every respect a process of gemmation. From this point onward, however, the fate of the pseudovum is different from that of the ovum. The former begins at once to be converted into the germ, the latter accumulates yelk substance, and changes but little. Both bodies acquire their membranous investment rather late; within it the pseudovum becomes a living larva, while the ovum is impregnated, laid, and remains in a state of rest for a longer or shorter period. Although then the pseudovum and the ovum of *Aphis* are exceedingly similar in structure for some time after they have passed out of the condition of indifferent tissue, it cannot be said that the sole difference between them is, that the one requires fecundation and the other not. When the ovum is of the size of a pseudovum, which is about to develope into an embryo, and therefore long before fecundation, it manifests its inherent physiological distinctness by becoming not an embryo, but an ovum. Up to this period, the influence of fecundation has not been felt; and the production of ova instead of pseudova must depend upon a something impressed upon the constitution of the parent before it was brought forth by its viviparous progenitrix. In this respect the ova of *Aphis* exhibit the same relation to the pseudova as the ephippial eggs of *Daphnia* (whose development has been so well described by Mr. Lubbock) bear to the agamic eggs; for the histological change in the ovarium of the *Daphnia* which precedes the development of the ephippial eggs, is already shown by Mr. Lubbock to have no relation to fecundation.

"Let me remark on yet another interesting, though perhaps only partial, analogy. Von Siebold has shown that the ova of the queen bee produce females or males, according as they are fecundated or not. The fecundated ovum produces a queen or a neuter, according to the food of the larva and the other conditions to which it is subjected; the unfecundated ovum produces a drone. Now, what have we seen in *Aphis?* The fecundated egg produces viviparous *Aphides*, which are the equivalents of the neuter bees, and from these are eventually produced males and oviparous females. The oviparous females are fecundated and lay eggs, which produce only viviparous or neuter *Aphides*. On the view which Dr. Carpenter and myself take of the zoological individual, the whole produce of the single fecundated ovum of the *Aphis* is as much the *Aphis* individual, as it is the bee individual. Consequently we have two equivalent and related series.

Bee	Impregnated ova producing	Neuters or females.	producing	Ova requiring impregnation, and males.
Aphis		Viviparous neuters.		Females, which give rise to ova requiring impregnation, and males.

The fact that in the one case the males are developed from pseudova resembling fully-formed true ova, and in the other from pseudova resembling imperfectly formed ova, makes no essential difference in the analogy, but only demonstrates still more clearly the impossibility of drawing any absolute line of demarcation histologically between ova and buds."

If this position be established, it becomes evident that gemmation suffices to produce the same result as the ordinary mode of generation in which fecundation plays so important a part. What, it may be asked, does the bud possess which is not possessed by the unfertilised ovum? and why should fecundation be necessary in the one case and not in the other? These questions have an important bearing upon the modes of reproduction in all the lower animals. In the *Aphis* it would seem that the viviparous individual has warmth and abundance of food, while the oviparous individuals have a lack of one or both. In a second part of his paper, Professor Huxley gives an outline of the embryogeny of the *Aphis;* but those who require information are referred to the original. (Huxley, 'On the Agamic Reproduction and Morphology of *Aphis;*' 'Trans. Linnæan Society,' vol. xxii. pp. 193—236.)

It will be noticed that the soundness of the above arguments mainly rests upon the assumption or proof that the viviparously born individuals are derived from unimpregnated germs. From the competence of Professor Huxley, and other persons who have taken his view on this point, we may feel confident there is no external impregnation, but further investigation is required before we can positively assert there is no internal impregnation. M. Balbiani has written in support of the latter view. He maintains that the embryo viviparous *Aphides* are hermaphrodites. Moreover, he finds a similar apparatus in many other species which are considered to be parthenogenetic. If Balbiani is correct, both parthenogenesis and agamogenesis will have to be abandoned.

(*Comptes Rendus*, lxii.; *Annals of Natural History*, 3rd series, vol. xviii.)

APTERYX [E. C. vol. i. cols. 276, 277]. This genus, which is probably on the verge of extinction, presents a remarkable combination of characters. In many points it is unusually simple in construction for a bird, while in a few it has considerable analogy with the great Mammalian group. There are few genera in which the scapular arch is so small, the pectoral muscles so weak, the sternum so flat, and the humerus so short and slender; and yet there are few in which the muscles of the legs and external integuments are so fully developed. The whole osseous framework, and the muscular development, would alone suffice to convince us that the bird possessing them was more terrestrial than aerial, a runner upon the ground, rather than a flier in the air. Professor Owen, referring to the cutaneous system of muscles, states that it presents a distinct and extensive development connected with the peculiar structure of the integument, and probably with the burrowing habit of *A. australis*, which thereby possesses the power of shaking off the loose earth from its plumage, while busy in the act of excavating its chamber of retreat and nidification. The whole of the neck is surrounded by a thin stratum of muscular fibres, directed for the most part transversely, and its purpose is to brace the skin of the neck, raise the feathers, and, with the help of a muscle which passes from the neck to the breast bone, to shake them ('Comp. Anat. of Vertebrates,' vol. ii. pp. 109, 110). The scapular arch in the adult *Apteryx* is scarcely more developed than the same part in the embryos of most other genera. It retains in a permanent ossified condition the same phase of development which is temporary in the young chick or eagle. Combined with its inability to fly, there is associated another remarkable feature, in which it departs from the prevalent ornithic type, and approaches the more terrestrial vertebrates. That feature is the absence of air cells, whereby the bodies of most birds are rendered so specifically light, and the presence of marrow in all the hollow bones. In this last point it again exemplifies a permanent condition of a phase which is temporary in most birds, whose bones are first filled with marrow, and by subsequent development become more or less permeated with air. The feathers also of the *Apteryx* differ from those of birds of flight; they are loose and pendent, the barbules also are loose, and do not lock into one another so as to give that firmness to the barbs which is so characteristic of a bird's wing; and there are no accessory plumes.

The *Apteryx* was at one time assigned to the order *Cursores;* but of late years many ornithologists have inclined to the belief that this order is not a natural group, but that it comprises the members of other orders more or less modified for a cursorial existence. Professor Owen considers *Apteryx* to belong to the Gallinaceous sub-order.

There are probably five species of this genus known, but two of them are based upon insufficient evidence. *A. Australis* occurs, though very rarely, in the New Zealand province of Otago; *A. Owenii* is plentiful in the province of Nelson; *A. maxima*, of which no specimen has we believe yet been seen, is also supposed to exist in the same province; *A. Mantellii* is common in the North Island; and there is said to be a fifth species on the west coast of the South Island, similar to, but smaller than *A. Owenii*, which possesses more slender legs, and a longer bill than that species.

All that appears to be known respecting *A. maxima* is, that Dr. Haast saw some tracks like those made by the common Kiwi, but much longer; and that the whalers say they have seen a large Kiwi, which they called 'Fireman.' Dr. Haast believes he has heard a still larger species in the great forests covering the Southern Alps of New Zealand. The call of the bird was so loud as to startle his party from their sleep.

In 1851 a specimen of *Apteryx Mantellii* was presented to the Zoological Society of London, and by them placed in their gardens in Regent's Park. In 1864, a second specimen was added to the first, and both are still alive. A third specimen was acquired in 1868. Observations made on these specimens, together with information obtained from some of the New Zealand natives, have added somewhat to our knowledge of the nidification of this species. The following extracts from letters written by Messrs. Manning and Webster, residents at Hokianga, refer to the statements of the natives. Mr. Manning writes: "Several years ago an old native who had been a great Kiwi hunter in the times when the Kiwi were plentiful, told me a strange tale about the manner in which the Kiwi hatches its eggs. I, of course, cannot vouch for the correctness of the story, but think it worth mentioning. He said the Kiwi did not sit like other birds *upon* the egg, but *under* it; first burying the egg in the ground to a considerable depth, and then digging a cave or nest under it, by which about one-third of the lower end was exposed, and so lying under the egg and in contact with the lower end, which came as it were through the roof of the nest or burrow. The appearance of the egg which I propose to send corroborated this statement, for two-thirds of its length (the small end) was perfectly clean and white, and about one-third (the large end) was very much discoloured and very greasy, evidently from contact with the body of the bird. The difference in the colour and condition of the ends of the egg was quite remarkable, and well defined by a circular line passing round the egg." Mr. Webster writes: "A fortnight ago, a native out shooting pigeons, discovered a Kiwi's egg protruding out of a small hole at the root of a Kawri tree; removing the egg, he put his arm, to the elbow, up the hole, and got hold of the parent bird. The egg and the bird I have secured. Does it not appear a strange position for the egg to be in? An old native, who professes to know something about them, states that they (the Kiwis) lay but one egg at a time. The nest is merely a hole scratched out by the bird, and generally about the roots of a tree where the ground is dry, the egg is covered with leaves and moss, the decomposition of which evolves heat sufficient to bring forth the young. The process takes six months. When hatched, the mother, by instinct, is at hand to attend to her offspring." The female *Apteryx* in the Zoological Gardens, though unmated, laid her first egg in June, 1859, and subsequently nine others. Two were produced each year; one early in the spring, and the second about three months later. She was frequently discovered *above* the egg, as though sitting upon it. Dr. Sclater, from the observations made by him, thinks it probable that the *Apteryx* lays one egg at a time, that it is deposited in a hollow tree, that the female incubates thereon, and that the *Apteryx* breeds twice a year.

(*Proc. Zool. Soc.* 1863, pp. 234, 235.)

ARCHÆOPTERYX, a genus of birds possessing some remarkable modifications of structure, from the Solenhofen slates. The earliest evidences of birds consist of numerous footprints in the New Red Sandstone of Connecticut, but until recently no evidence of a more positive nature, such as the remains of the skeleton, had been found in rocks anterior to the Tertiary; and hence some persons have suggested that the Pterodactyles, or flying reptiles of the chalk and oolite, were the precursors of the class of birds. For many years past some palæontologists have referred to certain appearances on the Solenhofen slates, which they suspected might be feathers; but it was not until about 1861 that an undoubted fossil feather was found in these beds. A description and figure of it was published by Meyer in 'Leonhard and Bronn's Jahrbuch für Mineralogie,' and in 'Palæontographica,' vol. x. This was an important discovery, since it afforded indubitable evidence of the existence of bird-like creatures as far back as the upper Oolite, supposing it to be established that the Solenhofen beds are of that age. The feather has the same general characteristics as those developed in the birds of the present day. In the same Solenhofen beds are found some of the older species of pterodactyl—a fact which, in the absence of further evidence, takes away even the plausibility of the view that there may be a genetic relationship between pterodactyles and birds, or that the former were the prototypes of the latter. The feather from Solenhofen is rather smaller than some of the larger quill feathers of the partridge, and, from its structure, probably formed part of the wing. The species to which it belonged was named *Archæopteryx lithographica* by Meyer. The discovery of the feather was soon followed by that of the larger portion of the skeleton of a bird in the same slates, in which the feathers of the wings and tail still occupied their original position relatively to the bones. This specimen is now in the British Museum, and has been elaborately described by Professor Owen in the 'Philosophical Transactions' for 1863, and by other writers in many of the scientific periodicals. The following woodcut, from Lyell's 'Elements of Geology,' shows the main peculiarities of the tail feathers as contrasted with those of the living vulture. In the tail of *Gyps Bengalensis*, seen from above in D, and sideways in E, the great tail feathers are attached to the last three or four caudal vertebræ, which are few in number, and very short, while the tail is terminated by the upwardly turned and laterally compressed massive ploughshare, or coccygian bone, *f*. This last character is conspicuous in most birds which have a powerful flight. In the running birds (*Cursores*) the coccygian bone is less extended in the vertical direction, so as to lose its ploughshare shape. In the brevipennate birds, such as the *Apteryx* and the auk, the caudal vertebræ are more numerous and relatively longer, approaching, to a slight extent, the old bird of Solenhofen. In all embryonal birds the terminal coccygian bone consists of two or more separate vertebræ, and in the young ostrich there are as many as 18 or 20 free caudal vertebræ—a character still more nearly approaching that of the extinct *Archæopteryx*, which has 20 or more in the adult state. It is on account of this peculiar feature that it has received the specific name of *A. macroura*, or the long-tailed ancient feathered biped —a feature unknown amongst existing birds. On this point Professor Owen remarks that "the terminal vertebræ, ungrasped by the pelvis in the embryo bird, may equal in number those of the ancient feathered fossil; and if such vertebræ participated in the ratio of growth of other parts of the skeleton without subsequent stunting and confluence, they would more or less repeat the strange and unique feature in the skeleton of *Archæopteryx;* but the metamorphosis of the tail which has taken place in the bird's skeleton in the transition from the mesozoic to the neozoic life periods of the class is analogous to that from the protocercal to the homocercal type of tail, which marks the progress in fishes from the palæozoic to the mesozoic periods." ('Anatomy of Vertebrates,' ii. p. 38.) In B, are shown two of the caudal vertebræ of the natural size and shape; it will be noticed how widely they differ from those of the vulture in their great length, their close similarity in character, and the absence of transverse processes. Another peculiarity of the fossil is the possession of two claws or hooks formed of the two digits on the anterior margin of the wing. In Professor Owen and Von Meyer's account of the British Museum fossil the cranium is said to be wanting; but Mr. Evans has detected certain impressions which he states represent part of the cranium and cast of the brain. He has also detected a jaw, with teeth attached, which he considers may have belonged to the *Archæopteryx.*

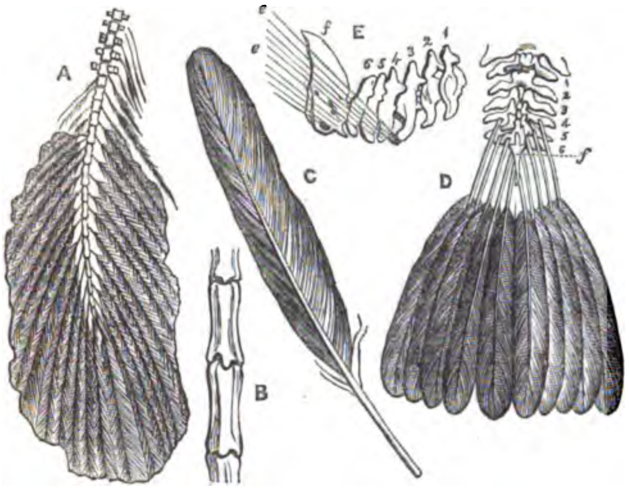


Fig. 1.—A, Series of caudal vertebræ (with impressions of the tail feathers preserved in situ) of *Archæopteryx macroura.* (Owen.) B, Two of the caudal vertebræ, showing their shape, and the absence of transverse processes. C, Feather upon which Mayer founded *Archæopteryx lithographica.* D, Tail of recent vulture (*Gyps Bengalensis*). E, Profile of caudal vertebræ of *Gyps Bengalensis*, showing the ploughshare bone, *f*.

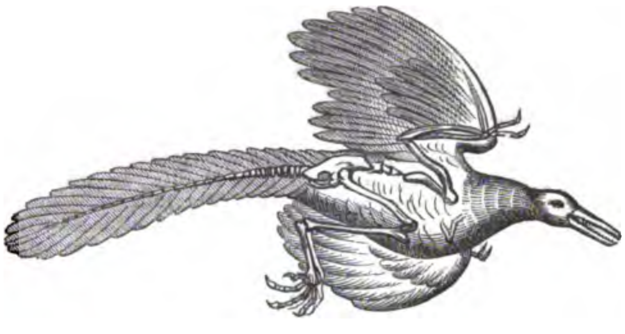


Fig. 2.—Ideal restoration of *Archæopteryx macroura.* (From Owen's 'Anatomy of Vertebrates.')

Mr. Parker, in his recent examination of the skeleton of the crested Screamer, a bird described under Palamedea, E. C., notices the number of the caudal vertebræ, and states that there are parts of its organisation which make it very probable that it is one of the nearest living relatives of the *Archæopteryx* [Chauna, E. C. S.]. The accompanying cut (*fig.* 2) is an ideal restoration of this bird, as given by Professor Owen.

M. Wagner assigned it to the Reptilian class, with the name *Griphosaurus*, on what are generally considered to be insufficient grounds. His argument is, in the main, that the birds as a class do not present much variation in their osseous structure as compared with the other vertebrate classes. The *Archæopteryx* possesses certain characters which are not to be found in birds, and therefore it should be excluded from the class. We will not contest M. Wagner's opinion, but will simply observe that there is no feature known to exist in the *Archæopteryx* which is not to be detected in the skeleton of the living birds. The differences chiefly lie in the degree of development of different parts. The embryo ostrich has the long tail, and the embryo parrot has tubercles in the jaw which have much analogy to teeth. It is, we believe, very doubtful if the *Archæopteryx* really had true teeth. [Birds, E. C.]

ARCHENCEPHALA, a name proposed by Professor Owen for one of the four sub-classes into which he divides the great class of Mammals. It embraces but one genus and species, viz., man (*Homo*). The terms in which it has been defined by Professor Owen in his latest work 'On the Anatomy of Vertebrates,' is as follows: In man the brain presents an ascensive step in development, higher and more strongly marked than that by which the preceding subclass (*Gyrencephala*) was distinguished from the one below it (*Lissencephala*). Although in the highest *Gyrencephala* the cerebrum may extend over the cerebellum, in man not only do the cerebral hemispheres overlap the olfactory lobes and cerebellum, but they extend in advance of the one and further back than the other. Their posterior development is so marked that anatomists have assigned to that part the character of a third lobe; it is peculiar, with its proportionally developed posterior ventricular horn and hippocampus minor, to the genus *Homo*. Concomitantly with the correspondingly developed anterior lobes of the cerebrum, the ventricle is, in like manner, produced into a horn-like form in advance of the corpus striatum. The superficial grey matter of the cerebrum, through the number and depth of the convolutions, attains its maximum of extent in man. Peculiar mental powers are associated with the highest form of brain, and these consequences strikingly illustrate the value of the cerebral character.

AUGITE [E. C. vol. i. cols. 341—343]. In the former article on this subject the reasons were given upon which Professor Rose founded his opinion that all the species belonging to the augite and hornblende groups should be united into one genus. He has since modified his views, and proposed that the two groups should be kept distinct, but yet closely connected together. This relationship consists in all the species of each group being completely isomorphous amongst themselves, and at the same time isomorphous with the corresponding species of the other group as regards their crystalline structure, but not so as regards their chemical composition. Later chemists, however, have concurred with Rammelsberg in believing that all the species of both groups may be expressed by the same general formula, and consequently that they possess both chemical and crystallographical isomorphism. Whether Rammelsberg's hypothesis be correct, the remarkable differences presented by the species of the two groups render it most convenient to keep them separate in our descriptions.

The augites are chemically regarded as metasilicates capable of being reduced to the general formula M SiO$_3$, in which the M stands for a diatomic metal, generally lime or magnesia, and less frequently the protoxides of iron and manganese, which may replace the former in every proportion. This is the normal composition, but there are species of augite which contain a larger proportion of silica than indicated in the formula, and also a considerable proportion of sesquioxides, such as alumina and peroxide of iron. The presence of these ingredients appears inconsistent with the views propounded by Rammelsberg, and some chemists have endeavoured to meet the difficulty by supposing that alumina may be isomorphous with the silica. M. Charles Deville, on the other hand, suggests that such species may be mixtures of a normal augite with an aluminate.

The augites are distinguished from the hornblendes by the cleavage planes being parallel to the faces M, M [*fig.* 1, AUGITE, E. C.], and consequently at an angle of about 87°, by fusing at a higher temperature, by their vitreous appearance and less brilliant lustre. The cleavages are less perfect in augite than in hornblende, and generally occur in an oblique direction and parallel to the lateral faces of the primary prism. Another distinctive point is that the augites cleave in a direction parallel to their base, whereas the hornblendes do not. This character is not a convenient one, since many augites and hornblendes which are composed of thin laminar crystals appear to cleave in this direction, but in such cases the planes are planes of separation, not planes of cleavage. There is also a difference in the mode of crystalline development; for, although theoretically, it is true that all the forms of crystals yet met with in augites and hornblendes may be derived according to certain definite crystallographical laws from the same primary form, yet practically the crystalline forms of augites have not yet been met with amongst the hornblendes. Moreover, the optical properties of the two classes of crystals are strikingly different. We may also mention here that generally speaking the hornblendes are more generally distributed amongst the plutonic rocks, while the augites usually form part of the volcanic igneous rocks. In some rocks, such as the basalt and trachyte of Etna, the two minerals are found together.

With this general view of the differences between the augite and hornblende groups, we will pass on to the species.

Diopside is a lime-magnesia augite which is transparent and colourless when pure, as in the case of the variety called *Alalite*, from Ala, in Piedmont. Generally, however, it is coloured by the protoxides of iron and manganese. The crystals are commonly translucent, and of various colours, from pure white to greyish white, yellowish white, greenish grey, and clear grey. They are doubly refracting, and the angle of the two axes is 59°. There are several varieties distinguishable by slight differences of colour and structure; thus white *Coccolite* occurs in saccharoidal limestone at numerous European and American localities; *Mussite* forms translucent or opaque greenish prismatic crystals in serpentine; *Traversellite* forms large, deep, green prisms, longitudinally striated, near Traversella, Piedmont; and the *Asbestiform diopside* derives its name from the loosely aggregated parallel fibres of which it consists. This last variety is frequently called asbestos, owing to the difficulty of distinguishing it from the corresponding asbestiform variety amongst the hornblendes.

Diallage.—This species has not been very accurately defined, but the term is generally applied to certain greyish-green crystals which contain about equal proportions of lime and magnesia; by an increase in the proportion of lime it passes into diopside; and by an increase in the magnesia it passes into diaclasite. Diallage also is richer in protoxide of iron than diopside. It forms small laminæ, sometimes in jade and sometimes in serpentine. In the first case, which is most frequent, it becomes an essential ingredient of diallage rock and euphotide.

Augite, or basaltic augite, as it is frequently called, is a bisilicate of lime, magnesia, and iron, and is usually of a dark green or black colour. It sometimes contains alumina, which in some specimens amounts to 12 per cent. It contains more iron than most of the other augites, and hence its colour is also darker than usual. It forms short and well defined crystals in such rocks as basalt, dolerite, black porphyry or melaphyres, and also in many lavas. Many of these rocks are largely composed of augite in a non-crystalline state; for example, dolerite is a mixture of labradorite and augite, in which the proportion of the latter may vary from 10 to 40 or 50 per cent. In other rocks also the uncrystallised portion of the augite far exceeds in amount the portion which is crystallised. Leucite rock is a compound of leucite and augite, and lherzolite consists almost entirely of augite.

In looking over the chemical analyses of the augites it will be noticed that nearly all contain as essential ingredients, or as accidental impurities, four oxides, viz., those of calcium, manganese, iron, and magnesium. And it is probable they may be mixtures of the four simple bisilicates, *Wollastonite*, the bisilicate of lime [WOLLASTONITE, E. C.]; *Enstatite*, the bisilicate of magnesia; *Rhodonite*, the bisilicate of manganese [MANGANESE, E. C.]; and *Grünerite*, the bisilicate of iron. Two of these were not described in the Cyclopædia, and we proceed to describe them here, in order that the characters of all these silicates may be compared with those of the more complicated augites.

Enstatite is a bisilicate of magnesia (Mg, SiO$_3$), which was formerly confounded with scapolite, but it is at once distinguished from it by its infusibility with the blowpipe. It is also essentially distinct from *Pyrallolite*, which is a hydrated bisilicate of magnesia and an alteration product of augite. Enstatite is anhydrous when pure. Its colour varies from greyish white to slightly greenish or yellowish. The crystals are derived from a rhombic prism, in which the angles are 93° and 87°. It cleaves most easily along planes parallel to the faces of the prism of 93°, while other cleavages occur parallel to the diagonal section of the same prism. H. = 5·5; and sp. gr. = 3·12. When pure it contains 59·71 per cent. of silica, and 40·29 of magnesia. It is then greyish or yellowish white, with a vitreous or pearly lustre along the planes of cleavage. When protoxide of iron replaces a portion of the magnesia the tints become greenish and brown, and as the proportion increases we pass on to specimens with a bronzy lustre. These form the variety *Bronzite*, which in the typical specimens contains 40 per cent. of magnesia, and 10 per cent. of protoxide of iron [BRONZITE, E. C.]. Enstatite is found crystallized in serpentine at Mount Zdjar in Moravia, and at Mount Bezouars in the Vosges.

Grünerite is a nearly pure iron augite (Fe SiO$_3$), found at Collobrières in the department de l'Aude, France. It is of a greyish colour, asbestiform, and with a specific gravity of 3·7. The specimen analysed by M. Grüner gave,

Silica	43·9
Protoxide of iron	52·2
Magnesia	1·1
Lime	·5
Alumina	1·9

A pure specimen would give 46·12 per cent. of silica.

B

BALÆNICEPS. This genus of birds was described by Mr. Gould in 1851; but up to the present time only one species, *B. rex*, has been discovered. In 1860 two specimens were forwarded by Mr. Petherick to the Zoological Society of London, and were the first to be exhibited in Europe. This remarkable bird has its home amidst the swampy morasses and shallow lakes of Central Africa, where it collects in small groups of from three to one hundred. Mr. Petherick gives an account of their habits. "If frightened," he says, "and fired at, they rise in flocks high in the air, and after hovering and wheeling around, will settle on the highest trees, and as long as their disturbers are near will not return to the water. Their roosting-place is, to the best of my belief, on the ground. Their food principally is fish and water-snakes, which they have been seen by my men to catch and devour. They will also feed on the intestines of dead animals, the carcases of which they easily rip open with the strong hook of the upper bill. The breeding-time of the *Balæniceps* is in the rainy season, during the months of July and August, and the spot chosen is in the reeds or high grass, immediately on the water's edge, or on some small elevated and dry spots entirely surrounded by water. The birds before laying make a hole in the earth, in which, without any lining of grass or feathers, the female deposits her eggs. As many as a dozen eggs have been found in the same nest."

The structure and appearance of this bird are so extraordinary that much discussion has been expended in endeavouring to determine what its affinities are. According to some its nearest ally is the boat-bill, *Cancroma*, of South America [BOAT-BILL, E. C. vol. i.]; Mr. Reinhardt contends it is the *Scopus* of South Africa; and others would place it either among the cranes or storks. The main peculiarities of *Balæniceps* relate chiefly to the structure and conformation of the skull. The bones are unusually thick, and there are few birds in which the projections for the attachment of muscles are so large. The upper surface of the skull is smooth, flat, and even concave at its anterior half. The eyeball is so large that the upper margin of the orbit rises above the middle part of the skull; and the skull itself is so short that the anterior margin of the orbit is advanced more forward than in most of its allies. The bill of this species is one of its most remarkable features; it has been thoroughly examined by Mr. Parker, to whom we are indebted for the following description. The marginal outline of the great upper jaw of the *Balæniceps* much resembles that of the leaf of *Magnolia grandifolia*. Its length is more than twice its breadth, whilst in the boat-bill the breadth is more than half the length, the upper jaw of the latter being more outspread. The degree of arching of the upper jaw is intermediate between that of the boat-bill and that of the stork (*Ciconia*). The gradual rise of the mesial ridge to form the great terminal hook, the crescentic notch forming the inferior margin of the beak, and then the graceful outward curve of nearly the entire mandibular margin, give great elegance to the lateral aspect of the upper jaw. At the end of that margin we have the commencement of the great cheek-bone, which is nearly two inches long, half an inch broad, and one quarter of an inch thick. Such a magnitude of the zygomatic arch as this is perfectly unique in the class of birds, being more like the development of the same part in most mammalia, in the crocodiles, and in the turtle. In the enormous heads of the larger horn-bills, the cheek bones are not half the size they attain in the *Balæniceps*. The os quadratum or tympanic bone, which forms so beautiful an articular medium between the cranium and lower jaw in birds, is strong and well developed. This bone and the little pterygoid, which intervenes between it and the palatines, have very much the character of the same bones in the heron and adjutant; but the palatine bones themselves, coalescing at the mid-line, and sending downwards a strong keel at that part, are exactly intermediate in structure between that of the adjutant and the pelican. These bones and the pterygoid at their point of juncture are beautifully scooped out to receive and glide under the strong beam of bone which forms the base of the interorbital septum. The great strength of all the bones forming the upper maxillary apparatus is in perfect harmony with what is known of the habits of the creature. In this respect it has no peer among its congeners, and no superior except among some of the large parrots. But the latter birds, although they possess the most perfect fronto-maxillary hinge, have nothing in their tympanics or malar bones at all comparable to those of the *Balæniceps*. Perhaps the most elegant part of this bird's structure is the hard palate, formed for the most part by the coalescent maxillary bones; the maxillaries in birds, as in typical fishes, having a very backward position, and often inferior development. Just inside the margin of the posterior angle, on the under surface of this great upper jaw, the bone is cut away, as it were, to receive the coronoid portion of the lower jaw. This excavated part is continuous anteriorly with a deep groove, margined internally by a short ridge, which gradually rises inside the palate to pass forwards in a sigmoid manner to the base of the great terminal beak, where it meets the submesial groove in the upper surface of the jaws. In the common heron these palatine submarginal lines exist, being covered in the horny sheath by sharp ridges. These ridges have their fullest development in the green turtle. The occipital condyle is here spherical and large, and the base of the skull has a very exquisite structure, which deserves full description, as it exceeds anything we have seen in birds, the heron making the nearest approach to the *Balæniceps* in this particular. Many other birds, however, show traces of this peculiar structure. The lower jaw is exceedingly strong and thick as compared with that of the adjutant. Less elliptical and more triangular than that of the boat-bill, it has, nevertheless, many of the characters of the latter. Its tip is curiously emarginate, as is also the tip of the upper jaw, the bony basis of the great hooked beak. The traces of suture between the dentary and other elements of the mandible, which are persistent in the boat-bill, adjutant, and most other birds, are all filled up with bony matter, as is the case in the parrot tribe, in the horn-bill, and in the toucans. The anterior part of the mandible passes within the maxilla, the edge of its bony sheath fitting between the marginal and submarginal ridge of the latter. Where the upper jaw begins to narrow towards its angle, there the mandible rises higher (its height or depth here being 1¼ inch), and it is rounded, rough, and strong. It then lowers again, and becomes rapidly broader to form the deep and wide articular cavities for the tympanic bone above, and the broad flat angular processes behind and below. Each ramus of this great inelastic mandible is united to its fellow at the symphysis by complete bony union to the extent of 1¼ inch. In the extremely elastic mandible of the pelican, this line of bony union is one-eighth of an inch in length; in the boat-bill, one-fourth of an inch; in the adjutant, 4½ inches; and in the horn-bill (*Buceros bicornis*), more than seven inches. (‘Proc. Zool. Soc.,’ 1860, p. 326.) Mr. Parker also treats in detail of the vertebræ, the sternum, and limbs of this species, and comes to the conclusion that it is strictly an Ardeine bird. Reinhardt, on the other hand, judging from external characters only, decides that *Balæniceps* is most nearly related to *Scopus*. He dwells more especially on the close resemblance between the beaks of the two species. In both, he remarks, the nostrils are shaped in precisely the same way; viz., as narrow, almost imperceptible, slits. In both the culmen is separated throughout its whole length from the sides of the bill by a deep, narrow groove or furrow, and both terminate in a powerful hook.

BALANOPHORACEÆ or **BALANOPHOREÆ**. [E. C. vol. i. 373.] This small but remarkable order of plants now comprises about 40 species, distributed amongst 15 genera. From the wide difference which these genera present among themselves, the order, as now known to us, appears to be a remnant only of what its full development would be. The intermediate forms have in all probability, once had a being, but have died out in past ages, or if they still exist, are now flourishing undiscovered in the dense damp woods of the warmer zones of the globe. They have generally been regarded as nearly allied to the curious root parasites, the *Rafflesiaceæ*. But Dr. Hooker's careful examination of extensive collections of specimens from all parts tends to show that they are exogenous flowering plants, in which the various organs have a remarkably simple structure. The flowers are generally unisexual, eminently polymorphous, and notwithstanding their simplicity of structure, possess a high degree of morphological differentiation. In Dr. Hooker's opinion the *Balanophoreæ* belong to the epigynous *Calycifloræ*, and should be placed near the *Halorageæ*. He supports this opinion by referring to the following affinities between the two groups :—(1.) Between *Cynomorium* and *Hippuris* in the one epigynous stamen on an ovarium, consisting of one carpel with a solitary pendulous ovule and simple style. (2.) Between the *Distyli* and *Halorageæ* a relation is established through the Australian genus *Loudonia*, which is a very peculiar form of the latter order, having four styles and only one cell to an ovarium containing one or two pendulous ovules. The tendency to suppression of the ovaria, combined with the constant presence of their styles, and the styles of the suppressed ovaries being in all respects similar to those of the developed ovary and equally perfect, is a very peculiar character, and is frequent in *Halorageæ*, though not confined to them : it is very conspicuous in *Gunnera*. The greater tendency to imperfection in the female than in the male flowers of *Halorageæ* is also a marked feature shared by *Balanophoreæ*. (3.) Between *Gunnera* and *Lophophytum* the affinity is so close, that the female flowers of these genera might be mistaken for one another ; and the male flowers of *Lophophytum* in their two stamens, linear anthers and basal short filaments, are absolutely identical with those of several species of *Gunnera* ; in the subgenus *Misandra* especially, the male flower often consists of only two small sessile calyx lobes, with two alternating stamens. (4.) If the female inflorescence of *Gunnera* and *Lophophytum* be compared, the affinity may be very easily perceived ; in each, short conical branches of the flower head project laterally from a stout axis, and are subtended by a large bract, and studded with a dense mass of flowers, which consist of an adherent perianth, no trace of rudimentary stamens, two styles, and a one-celled ovary with a pendulous ovule, whose integument in ripening contracts an adhesion to the inner wall of the cavity. (5.) The tendency to a dimerous or tetramerous arrangement of the parts of the flower so conspicuous in all *Halorageæ* and in *Gunnera* is common to the *Helosideæ* and *Lophophyteæ*.

It will thus be seen, that there is no relation between these plants and the *Fungi*. They differ from them completely in structure, in their slowness of growth, and in lasting for from one to several years. They grow from seeds, and are not propagated by bags of spores as stated by Endlicher. They abound most in the dense forests of the warm latitudes of Asia and America, but are usually met with on the slopes of the mountains rather than in the low-lying plains. Some species occur at considerable altitudes, and far within the temperate latitudes. Thus one species, *Cynomorium coccinum*, occurs as far north as the 41st degree of latitude in Europe. The distribution of the genera is thus indicated. *Mystropetalon*, *Sarcophyton*, *Thonningia* are African ; *Cynomorium* occurs throughout the whole Mediterranean area, and in the Canary Islands ; *Balanophora* extends over the Indo-Malayan region from Ceylon to the Himalayan mountains, and as far east as the New Hebrides ; *Rhopalocnemis* occurs in the Himalayan region ; *Langsdorffia*, *Lophophytum*, *Scybalium*, *Sphærorhizon*, *Phyllocoryne*, *Corynæa*, and *Helosis* are American ; and *Dactylanthus* is a New Zealand genus. Many of the species have so much wax in their cells that they are used as candles. Thus the stems of *Langsdorffia hypogæa* are used as candles on Saints'-days in the churches of Bogotà ; and *Balanophora elongata* is used for making candles in Java. (J. D. Hooker, *Linnean Trans.* xxii. p. 1—68, 1859.)

BARYTO-CELESTINE. [Strontia, E. C. S.]

BARYTO-STRONTIANITE. [Strontia, E. C. S.]

BASALT. [E. C. vol. i. col. 392—395 ; Giant's Causeway, E. C. vol. ii. cols. 1012, 1013.] This rock is defined by Cotta as being "A compact rock, nearly or quite black, with dull conchoidal fracture ; an apparently homogeneous compound of which the essentials are labradorite (or nepheline), augite, and magnetic iron ore, frequently united with carbonates and zeolitic substances. In the compact mass there often occur prominently distinct grains, or even crystals of olivine, labradorite, augite, and magnetic iron ore." It has a certain amount of resemblance to *dolerite* and *leucite* rock. The first differs from it in being granular, and in having a somewhat lower specific gravity ; while the second contains leucite in the place of the labradorite. *Anamesite*, *Analcymite*, and *Tholeite* are varieties of dolerite ; *Haunophyry* is a variety of basalt ; and *Dunite* is a variety of leucite rock.

Basalt has the same elementary composition as dolerite, but differs from it in containing water and volatile matter. It is generally very compact, but occasionally it is somewhat cellular, the cellules are large and rounded, and differ from those of dolerite which are small, irregular, distorted, and close together. This variety is sometimes called *vesicular scoriaceous basalt*, or *basaltic lava*, and is well exemplified by the basalts at Wolfsberg in Bohemia, at Velay in France, and by the Rouge Roche, near Puy-en-Velaye. The last-mentioned example closely resembles the scoriaceous lavas, yielded by active volcanoes, but it differs from them in containing water. M. Delesse regards this as an important difference, and rightly so, if, as he asserts, the water is not derived from infiltration, but belonged to the rock when it underwent aqueous fusion. Basalt possesses but little lustre, the paste is generally lithoid and granular, but under certain circumstances it acquires a slightly vitreous lustre by metamorphism. The olivine and augite have the same vitreous lustre, and other characters possessed by them when developed in lavas and furnace slags, but the labradorite, instead of possessing a vitreous lustre, has a peculiar waxy one combined with a greenish colour, and an easy cleavage ; it also contains water, which Delesse considers to be an indication that it was developed in an hydrated rock. This may be thought by some to be confirmatory of the view that the properties of basalt are due to its having been erupted beneath the sea ; but although it is true many basalts have been so erupted, the presence of the sea does not appear to be essential, since the basalts of Auvergne were certainly ejected when the district was dry land. These basalts are compact in the lower parts of the sheets, so that no greater pressure was required to give it such compactness than is due to its depth.

The metamorphic action of basalt on other rocks has been carefully studied by M. Delesse. Although it is undoubtedly a volcanic rock, there are instances in which it appears to have produced no metamorphic action. For example, at Carlseegen in Germany, a thread of basalt traverses a metalliferous lode containing copper-pyrites, and zinc blende, without having produced any effect on these minerals ; and at the Louise mine, Siegen, fragments of spathic iron are embedded in basalt, which appear to have undergone no other alteration than a slight change of colour. In the Alte Birke mine, close to the last, a vein of basalt repeatedly cuts a seam of spathic carbonate of iron, but in this case there has been a strong metamorphic action. The basalt varies from one to six feet in thickness, and is itself somewhat altered on the side nearest the metalliferous veins. The part of the veins which touches the basalt is converted into magnetic oxide of iron ; beyond this comes a band of black and partially-altered carbonate ; and lastly, at a distance of several inches from the basalt, is the unaltered carbonate. The basalt, on the other hand, contains olivine, iron pyrites, arsenical iron, 22 per cent. of carbonate of iron, and 7 per cent. of organic matter. The change undergone is certainly great, but there is nothing to show that heat affected it rather than aqueous agency, and the reducing action of organic matter. However, there are numerous facts which show that the metamorphic action of basalt is, in most cases, due to heat ; as, for example, where coal has been converted into coke ; ordinary limestones rendered saccharoidal ; porous rocks, such as grit, impregnated with zeolitic crystals ; and argillaceous rocks rendered lithoid, cellular, or amygdaloidal.

In dolerite the paste is anhydrous, more or less magnetic, cellular, and of a grey or blackish colour. In anamesite, the structure is so fine-grained that no distinct crystals are visible to the eye, but in ordinary dolerite, crystals of labradorite and augite are readily detected. The labradorite occurs in white translucid and fractured tabular crystals, and possesses a vitreous lustre ; these characters at once distinguish it from the labradorite of basalt. The augite occurs in black or greenish-black crystals, having a vitreous lustre. Olivine and hornblende are also sparingly developed, and likewise have a vitreous lustre. The magnetic iron ore sometimes occurs in distinct octahedrons, but zeolites and carbonates are rare, and generally absent. The matrix itself is made of the same ingredients, but chiefly of labradorite and augite ; the proportions, however, vary considerably in different specimens. Dolerite, like basalt, has an energetic metamorphic action on other rocks. It converts combustibles into coke, decomposes limestones or renders them granular and crystalline, calcines argillaceous and felspathic rocks, and vitrifies quartz and granite. It is abundant in all countries, especially in volcanic districts, and is produced by active volcanoes, as in the case of Ætna, whose lava principally consists of labradorite and augite. In addition to the minerals mentioned above, dolerite also contains, as accessory ingredients, nepheline, sodalite, melanite, mica, bronzite, hornblende, olivine, specular iron, &c. Analcymite contains analcime, and is probably an altered dolerite.

Leucite rock is a compound of leucite, augite, and magnetic iron-ore, and is usually of a lighter grey tint than dolerite and basalt, and in addition to leucite and augite, it may also contain crystals of dark magnesia-mica, sodalite, sanidine, labradorite, nepheline, olivine, hauyne, garnet, apatite, and zeolites. It forms the lavas of several volcanoes, as, for example, of Vesuvius; but it has not been met with under circumstances indicating a high geological antiquity, probably on account of the readiness with which leucite is altered into felspar, nepheline, and kaolin.

BEAR [E. C. vol. i., cols. 401—415]. There is little to add respecting the living species of Bears, of which a synopsis has been recently published by Dr. Gray of the British Museum. ('Proc. Zool. Soc.' 1864, p. 677.) In E. C. a portion of the family *Ursidæ* was treated of under BEAR, and a portion under URSIDÆ; but, for the sake of convenience, we reproduce here Dr. Gray's definitions of all the genera of the group, in order that it may be seen what relation the Bears proper have to the rest of the Ursine family.

Section I. BRACHYPODA. Toes straight, claws exserted.

A. Tail very short; body massive; limbs short; nose short; teeth 42. *Ursina.*

a. Sea Bears. Soles of the feet hairy, with a few bald pads. The tubercular grinder longer than the flesh-tooth. Lips slightly extensile. Cutting-teeth, $\frac{6}{6}$. Ears rounded, hairy.

1. *Thalassarctos.* Nose of skull produced, longer than broad. Front false grinders small; far apart. Upper tubercular moderate.

b. Land Bears. Soles of the feet bald; callous. Cutting teeth, $\frac{6}{6}$. Lips slightly extensile. Cover of nostrils, moderate. Ears rounded, hairy. Under-side of the base of the toes, hairy.

2. *Ursus.* Nose of skull produced, longer than broad; rounded above. Forehead convex, separated from the nose by a cross line. False grinders far apart, small. Palate flat. Brain-case swollen. Lower jaw, moderate.

3. *Myrmarctos.* Nose of the skull produced, much longer than broad; flat above. Nose, forehead, and front of crown all on one line. False grinders far apart, small. Palate concave. Brain-case compressed. Lower jaws large, elongate.

4. *Helarctos.* Nose of skull very short, as broad as long, forming a line with the forehead. False grinders crowded, large. Palate broad, flat.

c. Honey Bears. Soles of the feet bald; callous. Cutting teeth, $\frac{4}{6}$. Lips very extensile. Nostrils large, with a large cover. Front of palate bent up. Ears tufted. Under-side of base of toes bald.

5. *Melursus.* Nose of the skull produced, longer than broad, rounded above. False grinders far apart. Upper hinder tubercular, short.

B. Tail elongate; body and limbs moderate; teeth, 40.

* Head elongate; nose produced, mobile; under-side convex, rather bald; without any longitudinal central groove. *Nasuina.*

6. *Nasua.*

** Head ovate; nose short; under-side flat, hairy, with a central longitudinal groove. *Procyonina.*

7. *Procyon.*

Section II. DENDROPODA. Toes short, arched; claws retractile.

A. Tail prehensile; soles bald. *Cercoleptina.*

8. *Cercoleptes*

B. Tail bushy; soles hairy. *Ailurina.*

9. *Ailurus.*

The article BEAR, E.C., relates to what are called in the above synopsis *Ursina.* The following is a list of the species described by Dr. Gray, a few notes being made upon some of the forms.

1. *Thalassarctos maritimus.* Siebold mentions it as a member of the Japanese fauna.

2. *Ursus arctos.* Four varieties, and several sub-varieties are noticed by Dr. Gray. One of the varieties is named *grandis.* It occurs in the N. of Europe; and a specimen of it lived upwards of ten years in the Zoological Gardens, Regent's Park. It is quite as large as *U. ferox;* and Dr. Gray is inclined to believe it will turn out to be a distinct species from *U. arctos.* Another variety is *collaris,* noticed in E. C., vol. i., col. 407, as *U. collaris.* It has been found in Kamtchatka, Amoorland, and Japan.

This species has been gradually diminishing in, and retreating from, its old haunts. It no longer roams through the Alps; the last indigenous specimen having passed out of existence in 1595, or shortly after. It was also towards the end of the sixteenth century that the brown bear was extirpated from the island of Corsica. The evidence bearing on this point consists of certain documents in the archives of most of the Corsican towns. Some of them are public notifications of the appointment of certain persons to the office of hunters of bears, boars, and stags. A translation of one of these is given by Aucapitaine in the 'Revue et Magasin de Zoologie,' Second Series, xiv. p. 262. It is dated July 28, 1572. It states that bears attack the flocks, and stags and wild boars ravage the crops belonging to the inhabitants of Vizzani; and beseeches the governor of Corsica to allow a certain person selected by the people of Vizzani to carry an arquebuss, in order that he "may defend and preserve our flocks, and prevent our ruin from the ravages of the bear, wild boar, and stag." It is probable the bear did not exist long after this date, since there is no evidence of its existence in the island after the end of the sixteenth century.

3. *U. Isabellinus.*

4. *U. Syriacus.*

5. *U. torquatus.* This is the *U. Thibetanus* of E. C. vol. i. col. 407.

6. *U. Japonicus.* This is believed to be a new species from Japan. Its fur is black, short, dense, and shiny; the hair on the sides of the neck is long. The face is clothed with short hair. The ears are large, and the head short and round. There is an ill-defined white line on the throat. Its habitat is Japan. Specimens have been exhibited in the Zoological Gardens, Regent's Park.

7. *U. Formosanum.* This is supposed to be a distinct species by Swinhoe, who states that it dwells in the high mountains of the interior of Formosa. It is intermediate in size between *U. japonicus* and *U. torquatus;* and, according to Dr. Sclater, it is scarcely distinguishable from the latter in external appearance.

8. *U. inornatus.* It is a native of Ceylon.

9. *U. cinereus.* It is the *U. ferox* of E. C. vol. i. cols. 405 *et seq.*

10. *U. horriaceus.* This is the barren ground bear of E. C. vol. i. col. 403.

11. *U. Americanus.*

12. *U. cinnamomeus.*

13. *Myrmarctos Eversmanni.* The ant-bears have long been overlooked. They have generally been considered to be the same as the brown bear. Eversmann recognised the difference as long ago as 1840, when he stated that "in the ant-eating bear the skull is more elegantly formed [than in *U. arctos*]. The anterior level of the frontal bone forms a plane with the nasal bone; the forehead also does not stand forwards, and forms no depression, but is flat. The molar teeth are narrower and longer; the zygomatic arch is thinner and more slender; altogether the entire skull is proportionally longer, not so high, and not so robust as in the carrion eater (*Ursus arctos*)." The species is a native of Norway. Probably a second exists in Eastern Siberia.

14. *Helarctos Malayanus.* A native of Sumatra, Borneo, Java, and the Malay peninsula.

15. *H. euryrhinus.* A specimen is so named in the Academical Museum of Lund, which is said to have been brought from Hungary.

16. *H. Crowtheri.* A north-west African species.

17. *H. ornatus.* It is the same as the *Ursus ornatus* of E. C. vol. i. col. 405.

18. *Melursus labiatus.*

In entering upon the consideration of the fossil bears, we are met by the difficulty as to what is to be considered a species, and what are the rules whereby we should be guided in the determination of specific forms. What reasons can be brought forward for accepting or rejecting the opinions of Cuvier or of Blainville? Cuvier admitted three fossil species, viz., *U. spelæus, U. arctoideus,* and *U. priscus.* Subsequently other authorities added *U. Pitorrii, U. giganteus,* and *U. leodiensis.* De Blainville regarded all these six species as one only; and, moreover, he held the opinion that the recent *U. arctos, U. Americanus,* and *U. ferox,* are varietal forms of the same comprehensive type. Whatever be the position we may adopt between these two extremes, there is unquestionably a certain amount of variation in form and proportions in the different individuals born of the same mother, in the different members of the same race, in the different races or breeds of the same variety, and in the different varieties of the same species. If mere divergence of characters is held to constitute the basis of the several zoological groupings, what amount is deemed requisite to separate species from species? and is the amount which suffices to separate one bear from another, similar in extent to that which is acknowledged to be sufficient to separate one species from another in the allied group of digitigrade carnivores? Or again, it may be asked if specific distinction may not depend rather upon the constancy of the divergence of character, than upon the amount of divergence itself? and if it can be admitted that the amount of difference which distinguishes one species of *Felis* and another is not greater than separates two varieties in the genus *Ursus?* These are questions which we shall not attempt to answer; but they may be usefully borne in mind in considering the details which follow. The palæontologist has a far more difficult task than the zoologist in determining specific forms. The former generally has but a few osseous fragments of a few individuals to assist him; while the latter usually has opportunities of studying the external characters and habits of thousands of individuals. Hence it is a great advantage when a few living forms can be studied, and the data supplied by them used in forming our opinion respecting the congeneric forms that have passed away. This task has been partially done for the genus *Ursus.* M. Delbos has made a most elaborate examination of *Ursus arctos, Ursus spelæus,* and other extinct forms bearing specific names; but it yet remains for some anatomist to make a similar examination of the structural conformation of the species which still co-exist with *U. arctos.* Few persons are better fitted for the task than M. Delbos himself, who is, we believe, zealously prosecuting it. In his first paper (Annales des Sciences Naturelles, 4th Series, vol. ix. p. 155-223) he gives details respecting almost every bone in the brown bear of the Pyrenees, and compares them with what is seen in the dog, which is taken as the type of the digitigrade carnivores. As an example of his mode of treating his subject we will condense his remarks upon the skulls of the two species. The palate is triangular in the dog, whereas it is like a quadrilateral whose fore angles have been rounded off in the bear. The space between the pterygoid crests of the bear is nearly two-thirds the width of the palate, and one-fourth of its length. In the dog it is only one-half as wide as the palate, while its length does not exceed one-third that of the palate. The mastoid process is attached to the temporal, and forms a prominent knob immediately behind the meatus auditorius, or ear-aperture. A large prismatic tubercle, which forms part of the occipital, and in front of which passes the squamoso-occipital suture, is connected with a ridge on the squamosal, and completes the mastoid process. In the dog the mastoid process is not on the squamosal, but on the occipital, and in some instances it is not developed at all on one side. The pre-maxillaries rise somewhat beyond the middle of the nasals, so as to be articulated with a triangular prolongation of the frontal. From this point, the frontal-maxillary suture ascends as high as the posterior third of the orbit, from whence it again descends, obliquely, to the lachrymal, which is entirely within the orbit. In the dog the pre-maxillaries do not ascend above the lower third of the nasal bones, and are not connected with the frontal. The incisive foramina are entirely in the pre-maxillaries which slope under the portion of the palate formed by the maxillaries. Between these two foramina and one situated more backwardly, is a third much smaller, situated on the suture of the two incisive bones, and which does not exist in the dog. In the dog, also, the maxillaries contribute to form the boundary of the incisive foramina. The malar is somewhat more prominent at the base of the zygomatic arch. The zygomatic process does not extend as far as the postorbital process, as in the dog. The palatine enters more largely into the formation of the orbit. From its articulation with the pre-sphenoid, in front of a round foramen, its margin is straight as far as the lachrymal bone. The pre-sphenoid is, on the other hand, much smaller. After it has contributed to form the spheno-orbital foramen the ali-sphenoid terminates at a slight distance therefrom, being intersected by the squamosal and palatine. In the dog the ali-sphenoid advances much farther, and even as far as the postorbital processes. The basi-sphenoid reaches farther into the temporal fossa and orbit; its ala, pointed anteriorly, stretches beyond the optic foramen. It is articulated below with the frontal and pre-sphenoid. In the dog it is intersected in front by the two bones just named. The lachrymal canal is formed by the lachrymal and maxillary bones; and is placed on the anterior edge of the orbit just above the origin of the zygomatic arch. In the dog it is entirely formed in the lachrymal; it is situated in the orbit and behind the upper branch of the suborbital. The suborbital foramen is much nearer the root of the bone so named; it there forms a slope situated above the penultimate molar. It emerges in the orbit, as in the dog; but it occurs on the line of separation of the palatine and maxillary, and the lachrymal does not contribute to its formation. The posterior suborbital foramen, the remnants of a membranous space which is liable to be obliterated with age, is situated between the lachrymal and anterior suborbital foramen on the suture of the lachrymal with the palatine. It is at the anterior angle, and less within the orbit than in the dog. The spheno- and pterygo-palatine foramina have the same position as in the dog. The second opens upon the palate by three channels. The anterior channel terminates in the interval between the two last molars on the suture of the palatine with the maxillary, and is continued forward as a groove on the palate, which widens and shallows until it vanishes; the middle channel is narrow, and like the posterior one, which is still smaller, is situated in the palatine. The orbital foramen is smaller than the optic, and these, together with the spheno-orbital and round foramina, are arranged lineally below a ridge which extends from the upper edge of the spheno-orbital foramen to the postorbital process of the frontal, and which has no existence in the dog. The oval and round foramina are pierced, as in the dog, in the basi-sphenoid; the spheno-orbital foramen is on the suture of the basi- with the pre-sphenoid; but the optic and orbital foramina are excavated in the frontal. In the dog the optic foramen is in the pre-sphenoid. The apertures of the Eustachian tube and carotid canal are very small, very irregular, and protected by a plate forming the anterior edge of the tympanic bone. The lower jaw, independent of the teeth which it supports, has characters which suffice to distinguish between genera, and even species. In *Ursus arctos* the two rami meet at an angle of from 55° to 60°. Each ramus, measured from the front alveolar edge to the back part of the last molar, is two-thirds of the total length, measured from the alveolar edge to the centre of the condyle. These proportions would, however, necessarily vary according as the individuals had long or short snouts. Near the symphysis there are numerous perforations for the passage of minute arteries. A short distance from the symphysis, towards its upper third, is a large foramen on either side; but their existence is not constant. The ramus is depressed behind the canine, and in the space which separates it from the first molar. There are three mentary foramina. The first two, in close apposition, are placed below the diastema, the anterior being in the upper third, while the middle one, and largest, is near the middle portion of the jaw. The third, somewhat isolated from the others, occurs below the interval between the first and second molars. The masseteric fossæ are shallow, and in the form of a triangle with a rounded apex, whose base is formed by the posterior margin of the maxillary. The two sides of the triangle are formed above by the slightly-raised ridge which constitutes the anterior edge of the coronoid process, and below by a still less marked swelling which merges into the angular process. On the inner surface the dentary canal is well developed, and situated just below the anterior edge of the coronoid process, behind the vertical depression on the posterior margin of the last molar, and at about equal distances from the upper and lower margin of the maxillary. The coronoid process approaches a right-angled triangle in general outline, the convex anterior edge representing the hypothenuse; while the concave posterior margin forms a large sigmoidal curve. Below this curve, and in a line with the molar teeth, is the condyle, with its very short neck. Below the condyle is a second curve, which is nearly semicircular. It separates the condyle from the angular process, the point of which is turned somewhat inwardly. Its lower margin merges into the external face of the maxillary, and forms the lower boundary of the masseteric fossa. The inner surface of this process presents a rough patch of an elliptical form, which is doubtless the place where the inner pterygoid muscle is inserted. The curve which separates the angular process from the lower edge of the maxillary is terminated anteriorly by a minute pyramidal projection, which is sometimes bituberculated, and which is situated just beneath the orifice of the dentary canal. Its apex, which points backwardly, limits a groove which proceeds inwardly, and which probably protects a facial artery. In front of this process commences the long straight space on which the mylo-hyoidean muscle is inserted. From the above-mentioned process the lower margin of the jaw is slightly convex as far as the extremity of the mylo-hyoidean impression; it then continues straight to the symphysis, when it makes a sharp curve to form the chin.

In the dog the two rami meet at an angle of 30°. The dentary portions form nearly three-fourths of the total length of the maxillary. There are only two mentary foramina, placed one behind the other, a little below the mid height. The anterior one is the largest, and occurs under the first premolar, while the second is under the third. The masseteric fossa is much deeper, more sharply defined anteriorly by the ridge on the forepart of the coronoid process, and below by that which extends to the angular process. There is, moreover, a third well-marked ridge, which commences at the junction of the two already mentioned, and stretches to the external margin of the condyle. This ridge is absent in the bear; it is bounded above by a triangular rugose surface situated beneath the main fossa, and which receives a portion of the masseter muscle. The orifice of the dentary canal is much nearer the condyle and below the mid height of the maxillary. The coronoid process is rather more sloped in a backward direction, so that it acquires more the shape of an obtuse-angled triangle. The small sigmoidal curve is shorter; its contour resembles that of a semi-ellipse bisected along its major axis. The angular process is nearly in the same plane as the maxillary, while in the bear it is on a line with, sometimes even slightly below, the lower margin of the maxillary, and it projects a little beyond it exteriorly. There is no tubercle on the lower margin marking the place of insertion of the mylo-hyoidean muscle, so that the regularity of contour of this margin is unbroken from the angular process to the chin.

The author then proceeds to notice the difference presented by the 40 vertebræ which compose the vertebral column, of which 7 are cervical, 14 dorsal, 6 lumbar, 7 sacral, and 6 caudal, and points out the admirable modification and specialization of character which they undergo as we pass from the neck to the tail. The sternum, the ribs (of which there are 14 on each side), the scapula, the long bones of the fore limbs, the long bones of the hind limbs, the numerous metacarpal and metatarsal bones are successively described; and the elaborate memoir is terminated by tables, in which are indicated the dimensions of each portion of the skeleton.

Having formed a clear idea of the features of the ursine skeleton, and having satisfied himself that it was possible to assign characters whereby almost every bone in the skeleton of a dog could be distinguished from the homologous and analogous bones in the skeleton of a bear, he extended his inquiry by comparing the ursine and the feline skeletons. The lion was selected because the cave-lion and the cave-bear have left abundant remains in the bone-caves of Europe, and because the cave-lion is the only species which approached the cave-bear in size, and whose bones were likely to be mistaken for those of the bear. The result he arrived at was, that with the exception of the least specialised bones, such as the ribs and the sternal pieces, every fragment of the skeleton could be assigned without hesitation to the genus to which it belonged.

Advancing a step further, he endeavoured to ascertain whether or not he could trace osteological differences of specific value, in accordance with the results obtained from external characters. As this part of the inquiry could only be based upon an examination of living forms, he selected the four Cuvierian species, viz., *U. arctos*, *U. niger*, *U. Americanus*, and *U. maritimus*, as the special subjects for investigation. They differ unequally from one another; thus *U. maritimus* differs far more from the other three than they differ among themselves, while *U. arctos* and *U. niger* resemble one another more than either resemble *U. Americanus*. The whole amount of difference is, however, comparatively so slight that all the species must be regarded as closely allied forms. This difference is less in extent than between the cat and the lion, which are universally admitted to belong to the same genus.

On examining individuals of the same species it was found that they varied according to age, sex, and idiosyncrasy. The variations presented themselves in four distinct ways—in the configuration, in the relative proportions of the different dimensions, in the proportions relatively to other parts of the skeleton, and in the absolute volume. Two homologous bones are said to have the same configuration when their processes, foramina, ridges, articular surfaces, muscular indentations, are similar in number and position; and if the pieces are of a compound nature, such as the cranium or pelvis, when the bones composing each are similar in number and relative apposition. In this respect no essential differences could be detected within specific limits, whether the species was a *Felis* or an *Ursus*. In ascertaining the variations in the dimensions of the same bone, one of the dimensions was selected as the unit, in terms of which the variation was estimated. In this respect the brown bear presented notable differences. The most constant characters appear to be the relative widths of the cranium and face, and of the zygomatic arches; the next most constant were the width of the forehead, the height of the point at which the temporal crests met, of the most projecting and most depressed parts of the cranium, and of the nasal bones. All the other parts varied in the ratio of 2 to 3, or even 1 to 2. In the long bones the width of the upper end of the tibia may vary in the proportion of 3 to 4, and that of the lower end of the femur in the proportion of 4 to 5. As respects the relative proportions of the bones one to another, the relative size of the legs is known to vary according to age and sex, and even in the individuals derived from the same mother. The absolute size also presents variations. Many instances are known in which young bears not more than three years old have exceeded their mother in size. The length of the cranium may vary in the ratio of 4 to 5; that of the humerus in the ratio of 3 to 4, and so on with many other bones. Moderate differences of size cannot, therefore, be accepted as indicating in themselves any specific distinction, since acknowledged individuals of the same species may differ by as much as one-third.

Turning our attention next to the four species of bear above mentioned, they vary in all the four ways indicated. The differences of configuration are but slight. The temporal and sagittal crests are slight or absent in *U. arctos* and *U. maratimus*; but well marked in *U. niger* and *U. Americanus*. The number of teeth is the same in all; but the internal tubercle of the first true molar above is rudimentary in *U. Malayanus*, but is more developed in other species. The small premolars which are spaced out in most species are inserted close together in the bear of Java. The bear of the Cordilleras resembles the genus *Felis* in having a foramen in the inner condyle of the humerus, but this foramen is wanting in all the four Cuvierian species. In all other respects there is no difference of configuration; there are the same sutures, the same connections, the same foramina placed in similar positions. In the genus *Felis* the differences of configuration are greater. The first two lower molars are trilobed in the panther and leopard, and four lobed in the cheetah; while in the lynx the small anterior molar is absent. Again the tenth and eleventh dorsal vertebræ present marked differences in the lion and in the domestic cat. The variations in the relative proportions of the homologous parts are so great in individuals that it is difficult to distinguish the features which are more especially determinative of the species. Thus the variation in the sizes of the heads of all the four Cuvierian species is not greater than is met with in *U. arctos* alone; and yet we can distinguish (1) the polar bear by the elongate and cylindrical form of its head, the greater straightness of its face, the longitudinal depression in the middle of its muzzle, and the slight elevation of the cranium above the face; (2) the brown bear by its longer face, its more irregular forehead, by the more marked yet uniform curvature of its face, and by its generally convex forehead; (3) the black bear of Europe by its yet longer muzzle, the prominence of its eyebrows, and its flat forehead; and (4) the American bear by its short muzzle combined with a convex forehead. The characteristic differences thus appear to be the relative lengths of the cranium and face, the width of the skull, its height, the length of the temporal crests, the more or less conical form of the muzzle, and the width of the forehead. They are, however, to a certain extent obscured by individual variations of a similar character. As regards the variations in the relative proportions of different parts of the skeleton, the polar bear is at once distinguishable by its long neck and body, and the great size of its fore and hind feet. Absolute size is a character of great importance in the genus *Felis*, but of far less importance among bears. In short, the living species of bears mentioned above are distinguished (1) by slight differences in the configuration of the bones, such as cranial crests, teeth, perforation of the humeral condyle; (2) by the different proportions of the homologous parts, such as the relative length of cranium and face, width of the head, height of the profile, &c.; (3) by differences in the proportion of parts relatively to the whole body, such as the length of the neck, body, feet, &c.; and (4) by differences of size.

It now remains to be seen whether differences of a similar kind are or are not to be detected amongst fossil bear bones; but we should mention that M. Delbos restricts his attention more particularly to *U. priscus*, *U. spelæus*, and *U. arctoideus*. *U. priscus* differs from the two other fossil species more than the living species differ among themselves. In maturity it has the small premolars which are absent in the other two species; its forehead is depressed and not marked with elevations, the profile is lower and regularly arched, and its size is constantly less. The two other species correspond in stature and the absence of the small premolars. In *U. spelæus* the forehead is raised far above the base of the nose; its temporal crests rapidly unite and amalgamate with the sagittal crest; and its inner humeral condyle is perforated. *U. arctoideus* has a more depressed forehead, longer temporal ridges, smaller canines; and its humerus, which is smaller, does not have a perforated condyle. But can the two larger forms be regarded as distinct species? Cuvier says there are two kinds of jaws, but Delbos says they do not differ more than do the jaw bones amongst the individuals of one and the same recent species; Cuvier appeals to the two kinds of radii, femurs, and tibias, one of which is long and slender, the other short and stout; but Delbos says he has seen as great a difference and even greater differences, not only in different breeds, but even in the different families of the same breed of brown bear. So far there is nothing to warrant the assertion that they indicate distinct species. As to the perforation of the humeral condyle it would certainly be an important character if it were constant. Cuvier had only seen it in one bone, while it was absent in hundreds of others obtained from the same caves which supplied the two kinds of crania. At present then it can only be accepted as an accidental phenomenon. The two kinds of crania do not differ much. The prominence of the forehead is greater in *U. spelæus* than in *U. arctoideus*, and in the last it is greater than in all the living species. But it should be remembered that the size of the frontal sinuses upon which this prominence depends varies greatly according to age and between one individual and another. The point at which the temporal and sagittal crests unite approaches nearer the forehead in proportion as the sagittal crest is elongated with age. The volume of the cranium is not a trustworthy character, since there is much individual variation in this respect. Hence M. Delbos believes *U. arctoideus* to be nothing more than a variety or race of *U. spelæus*. Upon similar grounds he believes *U. Pitorrii* is only a large race or variety of *U. spelæus*. The *U. giganteus* of Schmerling is the same as *U. Pitorrii*; his *U. spelæus minor* is a variety of *U. spelæus*; and the same remark applies to *U. leodiensis*. M. Delbos, then, admits but two species of bears from the caverns of Europe, viz., *U. priscus* and *U. spelæus*, while *U. arctoideus* is a variety of the latter. Next comes the specific identity or non-identity of *U. spelæus* with *U. arctos*; and this may best be seen by a consideration of the four kinds of differences. *U. spelæus* differs from *U. arctos* by its more prominent forehead, its stronger ridges, and by the curvature of the profile being less depressed towards the occiput. In *U. spelæus* the lower external incisor has its outer lobe more detached from the principal eminence; while the upper external incisor slopes more rapidly on the inner side. The small premolars have an exceptional existence both above and below. The first lower true molar has its principal tubercle rather anteriorly placed, and there are two tubercles, instead of one, on its inner margin. Of the two tubercles the anterior one is wanting in the brown bear. The large molars have more complicated and more numerous ridges. *U. spelæus* has the basal portion of the cranium more irregular in outline than *U. arctos*. The temporal fossæ are deeper, the face is proportionally longer, the temporal ridges meet sooner, the osseous plate of the palate extends farther back. The palate itself is narrower, the muzzle is more compressed, straighter, and less tapering; the forehead is narrower, more prominent; the profile is less curved, and the soft parts of the nose are more developed. These results are calculated on the assumption that the length of the basilar line is unity. The first upper true molar has the crown one-fourth longer than wide. The lower antepenultimate true molar is somewhat narrower in front. The femur is proportionally much larger; the tibia is more massive. All the metacarpal bones are thicker by one-third or one-half; the metatarsal bones are one-third larger, and the phalanges are much larger. The extinct species is remarkable for the relative shortness of its fore and hind limbs, and by the great width of its feet, more especially the fore-feet. The radius was about one-third shorter than the same bone in *U. arctos*, while the tibia was one-fifth shorter relatively to the size of the animal. Hence the extinct species stood lower on its legs. The feet had relatively the same length as in *U. arctos*, but the fore-feet were half as wide again, and the hind-feet one-sixth wider. As regards absolute size the extinct species was far larger than the brown bear. The head was one-third longer; the lower jaw was seven-tenths longer, the humerus two-fifths longer, the radius and cubitus one-fourth, the femur one-half, and all the other bones much longer in the large variety of *U. spelæus* than in *U. arctos*. The bones were also uniformly of stouter build. The smaller variety was also longer than *U. arctos*, but the differences were not so great as in the previous varieties. Thus, its lower jaw was two-fifths longer, the humerus two-sevenths, and so on with the other bones. In all these cases the measurements assigned to *U. arctos* are those of the brown bear of the Pyrenees, but there is a large race which approached the cave-bear in size; but the largest skulls of *U. spelæus* are one-half as large again as the largest skulls of *U. arctos*; the humerus was two-sevenths longer, but the radius and tibia had the same length. In the smaller variety of *U. spelæus* the humerus had the same length as in the variety *grandis* of Dr. Gray; while the femur and tibia are absolutely shorter. But if individuals of *U. spelæus* and *U. arctos* var. *grandis* of similar dimensions were placed side by side, the former would be at once distinguished by its bulkier build and the greater massiveness of its bones. From these data M. Delbos considers that *U. spelæus* is specifically distinct from *U. arctos*. That *U. spelæus* is really a distinct species from all the living forms is supported by the following considerations: It differs from the four principal living species by the absence of the small premolars, by an additional tubercle on the first lower molar, by the more elongated shape of the first upper molar, by the anterior narrowness of the lower antepenultimate, by the prominence of its frontal convexities above the root of the nose, and by the greater relative size of its extremities, more especially those on the fore limbs. It differs from *U. arctos* by its longer muzzle, relatively to the cranium, by the greater prominence of its sagittal and temporal ridges, by the more rapid union of the latter, by the narrowness of the base of the cranium, by the width of the zygomatic arches, by the greater elevation of the whole of the profile above the basilar line, by the sudden uprise of the profile above the nose, and by the more concave outline of the cranium from before to behind. It comes near to the black bear of Europe in the prominence of its ridges, and the length of its muzzle, but its crests converge more rapidly, its zygomatic arches are not so far apart, its profile is more elevated, and its forehead is more prominent as well as more convex. It is distinguished from the polar bear by its longer face, its more dilated eyebrows, the greater elevation of the cranial portion of the profile, and its more tapering muzzle. The polar bear has the cranium less elevated above the muzzle than in any other species of bear. It differs from *U. Americanus* by its cranium being shorter relatively to the face, its shorter temporal ridges, as also its wider and higher head. These characters are quite as decided as those which are held sufficient to distinguish the living species one from another; and as those relating to the dentition and prominence of the forehead are far more decided, it is concluded that the fossil species differ more from the living ones, than they do amongst themselves. If the living species are really distinct, the extinct forms have a still higher claim to specific rank.

U. priscus differs from *U. spelæus*. It has no frontal prominence; the small premolars are constant; the first lower molar has one tubercle less, and its principal cone is situated in the centre, not anteriorly; and the first upper molar has a longer crown. The cranium is flatter and lower; the profile has a more regularly convex curvature, and the skull of the adult is one-third shorter. It differs from the living species in the same degree as they differ among themselves, and should consequently be entitled to specific distinction. To a certain extent it combines characters which are distributed amongst the living species. Thus it resembles the brown bear in its profile, the black bear of Europe in its flat forehead and elongated muzzle, and *U. Americanus* by the prompt juncture of its temporal crests. But it differs from all in the width of the cranium at the temples and occiput. One of the omissions in the paper of M. Delbos is the exclusion of the grizzly bear from his living types; an omission which has been supplied by Prof. Geo. Busk. He states that in the size, proportions, and form of the teeth, and in cranial characters, *U. priscus* cannot be specifically distinguished from *U. ferox*.

It might be interesting to describe the pathological malconformations of the bones of extinct species, since they frequently afford indications of affinities. The subject has been discussed by several authors, but we must content ourselves with recommending the reader to consult the work of Dr. Zeis, entitled 'Beschreibungen mehrerer Kranken Knocken vorweltliche Thiere, &c.,' published in 1856.

The species which have been mentioned in the previous part of this article are either in existence or were living in the latest geological or post-pliocene period. As yet, few remains of an ursine type have been found in strata of an earlier date, but of the few the most interesting is the lower jaw-bone obtained from certain beds in Greece, which are assigned to the miocene period by Albert Gaudry. This bone combines characters which are now disassociated in the living world, some being distinctive of the plantigrade, while others form some of the characteristic features of the digitigrade carnivores. Some of the teeth closely resemble the homologous teeth in the genera *Canis* and *Felis*, while the configuration of the lower jaw corresponds with the same part in the bears. In the miocene beds at Eppelsheim, a lower jaw, having the same generic characters, has been discovered, which Dr. Kaup named *Gulo diaphorus;* but M. Gaudry points out that it is not a *Gulo*. He names the new genus *Metarctos*, and hence the Eppelsheim species will be *Metarctos diaphorus*. The Grecian jaw bone may or may not be specifically identical with that of Eppelsheim, so that for the present it is simply referred to the genus. Perhaps we ought to mention *Arctocyon primævus* in this place, since it is said to combine the characters of the bear and the kinkajou (*Cercoleptes*). Its remains have been discovered in the oldest beds of the Parisian tertiary basin.

There are a few other extinct species, or reputed species, which chiefly flourished in the post-pliocene, but of which no mention has been made. Considerations of space prevent any detailed notice of them; but they will be briefly referred to in connection with the few remarks we have to make on the geographical distribution of extinct or fossil bears. The most common form is the large variety of *Ursus spelæus*, which roamed in vast numbers throughout the greater portion of the Europæo-Asiatic continent in post-pliocene times. The remains found probably represent only a very small proportion of the total number of individuals that once existed. Dr. Buckland's observations on the black dust of Kuhlock cave has been already quoted in E. C., but this cave is only one of hundreds in which this species contributed equally largely to the dust of death. Thus, upwards of 4,500 bones of *U. spelæus* were obtained in one year from a single cave near Odessa, and Delbos obtained portions of at least fifty individuals from a very limited portion of the cave of Sentheim. We should here mention that all the deposits referred to in E. C., vol. i., col. 414, are either of post-pliocene age, or their age has not been determined. They may all be ranked as post-tertiary. This alteration is due to the meaning of the word tertiary being somewhat more restricted now than formerly. At one time geologists spoke of all strata later than the secondary, as being of the tertiary age; but now these same beds are separated into two groups, the older retaining the term Tertiary, while the more recent are Post-Tertiary. For further particulars as to the localities where remains of *U. spelæus* have been found, we refer to Caves, E. C. S., and Post-Pliocene, E. C. S.; while under Man, E. C. S., allusion will be made to the evidence adduced to prove that the cave-bear did not become extinct until after man's appearance. In the more southern parts of Europe the cave-bear was either non-existent or very rare; the genus was represented by other species, such as that whose remains have been found in the caves of Gibraltar, the south of France, and Italy. The most southerly locality we know of for *U. spelæus* is Rome. The *U. Bourguignati* of Lartêt has only been found in Central France; while the *U. planifrons* of Denny has not been detected beyond the limits of Great Britain. *U. Bourguignati* is a new species described by Lartêt in the 'Annales des Sciences Naturelles,' 5th series, tome viii., of which description the following quotation from the 'Quarterly Journal of the Geological Society of London,' is an abstract: "This bear's skull differs remarkably from all the living members of the genus, except the *Ursus maritimus*, and from all the fossil ones with the exception of the *Ursus priscus* of Goldfuss, and the *Ursus planifrons* of Mr. Denny. From these three also it is separated by points of difference which M. Lartêt believes to be of specific value. In the *U. Bourguignati* the palate is much narrower than in *U. priscus*. The two series of molar teeth do not converge so much, and their number is six on each side, on account of the persistence of the two small simple premolars, of which one is situated in front of premolar 4, and the other immediately behind the canine. In other respects there is the same dental arrangement as in *U. priscus*, except that the diastema between the two small premolars is greater. The carnassial or premolar 4 has its antero-external lobe higher, and its internal talon is less developed. The difference between the true molars are less strongly marked, and therefore more difficult to determine. A comparison with *Ursus planifrons* shows that the palate of that animal is proportionally much wider than in the French species. Nothing can be predicated of the form of the teeth, because they are all wanting in the former skulls. In the Polar bear the palate is narrower than in the French species; the two rows of molars have the same numerical formula (but instead of converging in front as in the two preceding fossil species with which *U. Bourguignati* has been compared, they approach one another behind), the diastema between the two simple premolars is longer, and premolars 3, 4, true molars 1, 2, occupy less space in the alveolar edge, while their transverse diameters are greater. In the carnassial tooth the internal talon is smaller, and instead of being raised by a stout tubercle, it presents normally only low rounded bosses on a base but slightly extended backwards."

BIRDS [E. C. vol. i. cols. 460—474]. In the original article the matter is arranged systematically. It begins with the bony framework, and then passes to the muscles and integuments which are supported thereby. It describes the organs by which the food is subjected to those physical and chemical agencies through whose mediation it is adapted for the reparation of the tissues. The instruments by which the system communicates with the external world, such as the brain, the eyes, ears, and other sensory media are also noticed; and separate sections are devoted to the reproduction and migration, the classification, and the geological distribution of this class of beings. We do not propose to take up each of these points for further consideration, although much might be written about all of them; but we prefer to devote the most of our space to a few remarks on the classification of birds, and on their distribution in space and time.

Whenever we take up the study of a biological group the points which first press upon our attention are the relations between the species, genera, and families; and the characters by which these groups may be determined. As yet naturalists have scarcely settled what a species, or genus, or family, or indeed any other group, really is. Some say these are conventional terms which have no counterpart in nature; while others are convinced that species, genera, and families, are natural groups, although there is frequently a difficulty in distinguishing them. This should not surprise us, seeing that there are few well established rules of classification; and that classifiers not only have different aims, but pursue those aims in different ways. When the object is simply to help a fellow-student to ascertain what creatures are indicated by the names which have been assigned them, a very different and much easier mode of procedure is required than when the object is to give a correct idea of the homologies and analogies of organized beings. Not only are the results obtained widely discrepant, but the two kinds of classifiers have totally different notions of what is meant by a species, genus, or family. In the one case the characters and names indicate little more than the group of individuals which the classifier has studied, and he may consider it as immaterial whether you call it a genus or family, as whether you choose to sort a set of papers into a parcel marked A or 1. In the other case the desire is to bring like and like next to each other, to separate those which are unlike by an interval as great as corresponds to their difference, and to give groups of the same value the same name. Many difficulties, however, present themselves, and not the least among them is what we may term the personal equation of the value of characters; each man having his own estimate of the value of a given amount of difference. If there were a graduated difference throughout organized nature —that is, if, on the supposition that 100,000 species were created, and were arranged in a natural order from 1 to 100,000, the difference between the fourth and fifth species were the same in kind and amount as between any other species having consecutive numbers—classification would be easy. If a few species were extinct, we should be able to infer how many were required to fill the gaps, and what their natural place in a classification. But in such cases all terms of a higher value than species would be merely arbitrary, without anything corresponding to them in nature. If many forms had become extinct, and had left no fossil remains, the living forms would occur in groups marked off one from the other in the classified arrangements. Such groups might be considered to be by some the natural exponents of terms of higher value than species; but, on the supposition we started with this would be an erroneous view. If, on the other hand, we suppose the 100,000 species were created differing from one another unequally both in kind and amount, there would clearly be far more difficulty in ascertaining what degree of difference is of specific value, and if many of the former were unknown to us, it would not be easy to say whether the apparent groups were or were not natural groups corresponding to terms of higher value than a species. But in nature we have other phenomena which greatly increase the classifier's difficulties. One is that in many groups, and birds are amongst them, the sexes differ more from each other than the sex of one species from the corresponding sex in another. This has been the source of so many glaring mistakes that some naturalists have endeavoured to work out their classifications on a different principle. They consider the degree of difference as of subsidiary importance, and give the first place to the degree of constancy in a character or group of characters, however slight or trivial they may seem. But whichever principle be employed, there still remains a certain haziness about the ideas attached to the words species, genus, family, &c. The best principle of classification we believe to be the last mentioned, provided it be based upon all the characters presented during the lifetime of each sexual modification of the species.

These preliminary remarks are to a certain extent irrelevant here, but they have some bearing upon the classificatory value of the group of birds. It has long been considered as one of the five vertebrate classes, and therefore equivalent to the mammals or the fishes; but, if we compare birds with mammals, we find there is a far greater range of difference among the latter than among the former, and that a family of mammals presents a wider extent of variation than a family of birds. From this point of view the class of birds appears to correspond rather with an order amongst mammalia; and this is the opinion which has been adopted by MM. Blanchard, Isidore Geoffroy St. Hilaire, Professor Owen, and others, in accordance with which they call families what are usually termed orders. Thus the order *Gallinæ* of Bonaparte corresponds in principle with the family *Gallidæ* of Blanchard. On the other hand, we observe that birds possess at least one character the constancy of which indicates that they may be an order in a class distinct from all the other existing classes. This character is the possession of feathers. If we grouped the vertebrates by a single integumental character, we should at once distinguish mammals by their hair, birds by their feathers, and the other vertebrates either by their scales or by the absence of any of the above-mentioned features.

If the rules of classification now in vogue were correct, each student should arrive at essentially the same result; but although we find that almost all classifications agree in general plan with that first proposed by Belon upwards of three centuries ago, still scarcely any two are alike. With few exceptions, all recognise the land birds to be distinct from the water birds. Many agree in subdividing these into groups, usually termed orders, which present considerable similarity as regards one classification and another; but the greatest difference lies in the distribution of the minor groups amongst the orders. In the E. C. much prominence is given to what are termed circular arrangements, but this method of classification finds little favour now. The classification which has for long been adopted in this country is Mr. G. R. Gray's modification of that proposed by Vigors, but even this does not meet with general satisfaction. We have not space to examine or give outlines of the numerous classifications that have been started of late years, and will, therefore, confine our attention to a few.

The first we will notice is that adopted by Professor Owen in his 'Anatomy of the Vertebrates,' vol. ii., 1866.

Aves.—*Animal*, vertebrated, oviparous, biped. Pectoral limbs organised for flight. *Integument*, plumose. *Blood*, red, warm. *Respiration* and *circulation* double. *Lungs*, fixed, perforated. *Negative characters*, no ear conchs, lips, teeth, epiglottis, diaphragm, fornix, corpus callosum, scrotum.

Order I.—Natatores.

Swimming birds. Toes united by a membrane. Legs placed behind the equilibrium, and body covered with a thick coat of down beneath the feathers.

Families.

1. *Brevipennatæ.* Examples: Penguin, auk, guillemot, grebe.
2. *Longipennatæ.* Examples: Skimmer, tern, mew, gull, petrel, albatross.
3. *Totipalmatæ.* Examples: Pelican, gannet, cormorant, anhinga, frigate bird, tropic bird.
4. *Lamellirostratæ.* Examples: Duck, goose, swan, flamingo.

Order II.—Grallatores.

Wading birds. Legs long, naked from above the distal extremity of the tibia downward.

Families.

1. *Macrodactyli.* Examples: Coot, rail, crake, screamer, jacana.
2. *Cultrirostres.* Examples: Boat-bill, crane, heron, ibis, stork, tantalus, spoon-bill.
3. *Longirostres.* Examples: Gambet, avocet, snipe, ruff, turnstone, sandpiper, godwit, curlew.
4. *Pressirostres.* Examples: Oyster-catcher, thicknee, plover, lapwing, bustard, courser.

Order III.—Rasores.

Scratching birds. Feet strong, provided with obtuse claws for scratching up grain, &c. Upper mandible vaulted; nostrils pierced in a membranous space at the base, and covered by a cartilaginous scale. Nest rude. Sternum with four, rarely two, deep fissures.

Sub-orders.

Gallinacei, or *Clamatores;* Polygamous. Examples: Megapode, peafowl, partridge, quail, pheasant, ganga, grouse, pintado, tinamou, turkey, curassow, guan.

Columbacei, or *Gemitores;* Monogamous. Examples: Dove, goura, vinago.

Order IV.—Cantores (*Oscines*).

Singing birds. Legs short and slender, with three toes before and one behind, the two external toes being united by a very short membrane. Sternum with one notch on each side; manubrium bifurcate. Larynx, 5-muscular. The brain arrives in this order at its greatest proportional size, and the organ of voice here attains its utmost complexity. Nests complex. Eggs usually coloured. Monogamous.

Families.

1. *Dentirostres.* Examples: Manakin, shrike, wren, wagtail, warbler, thrush.
2. *Conirostres.* Examples: Paradise bird, crow, starling, bunting, tit, lark, finch, grosbeak.
3. *Tenuirostres.* Examples: Sun bird, nuthatch, creeper.
4. *Fissirostres.* Examples: Swallow, martin.

Order V.—Volitores.

Moving solely by flight. Skeleton light, and highly pneumatic; sternum with a simple manubrium and a deep keel, in some entire, in most with two hind notches on each side; larynx trimuscular; intestinal cæca usually absent or large; wings powerful, in some long and pointed; legs small and weak, with few exceptions not used in locomotion; with the back toe short, sometimes turned forward (*Cypselus*) or wanting (*Ceyx*); the outer toe is reversible in some (*Trogon*), in others united to the mid-toe as far as the penultimate joint. Many nidificate in holes of trees or in the earth; the eggs are white and spherical. They are monogamous. The head is large, and in most the beak is remarkable for its length or width, or both. The gape is wide; the food is taken on the wing.

Families.	Examples.
1. *Cypselidæ.*	Swift.
2. *Trochilidæ.*	Humming-bird.
3. *Caprimulgidæ.*	Nightjar.
4. *Trogonidæ.*	Trogon.
5. *Prionitidæ.*	Mot-mot.
6. *Meropidæ.*	Bee-eater.
7. *Galbulidæ.*	Jacamar.
8. *Coraciadæ.*	Roller.
8. *Capitonidæ.*	Puff-bird.
10. *Alcedinidæ.*	Kingfisher.
11. *Bucerotidæ.*	Horn-bill.

Order VI.—Scansores.

Climbing birds. Toes arranged in pairs, two before and two behind. Most oviposit in holes of decayed trees. Larynx trimuscular. Monogamous.

Families. Examples.

1. *Ramphastidæ.* Toucan.
2. *Bucconidæ.* Barbet.
3. *Cuculidæ.* Cuckoo.
4. *Picidæ.* Woodpecker.
5. *Musophagidæ.* Touraco, or plaintain-eater.
6. *Coliidæ.* Coly.
7. *Psittacidæ.* Parrot.

ORDER VII.—RAPTORES.

Rapacious birds. Beak strong, curved, sharp edged, and sharp pointed; legs short and robust, with three toes before and one behind, armed with long, strong, crooked talons.

Family 1. *Nocturnes.* Example: Owl.

„ 2. *Diurnes.* Examples: Hawk, eagle, vulture.

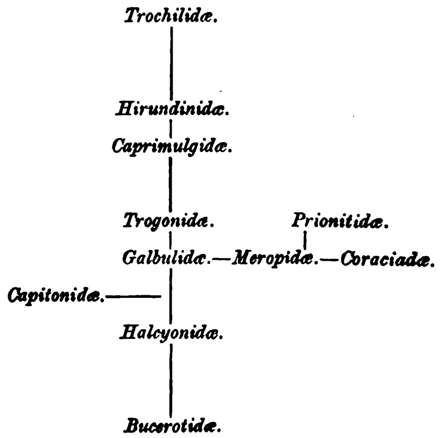
An eighth group of birds has been characterized, under the name *Cursores*, Coursers or running-birds, by the arrested development of the wings unfitting them for flight, and by the compensating size and strength of the legs, by which they are enabled to run swiftly on the ground. This is not, however, a natural order; some of its exponents have demonstrably closer affinities to other groups of which they are wingless members, just as the penguins and auks bear relation to families of the natatorial order. Thus the *Notornis* is a modified coot. The ostrich bears the same relation to the bustards. The extinct *Didus* and *Pezophaps* are most nearly allied to the Columbaceous group of *Rasores*. *Apteryx* and the allied extinct *Dinornis* and *Palapteryx* bear affinity to the megapodial family of *Gallinæ*. In all the Cursorial genera the sternum is devoid of keel. *Struthio* is the only genus of birds in which the toes are reduced to two. In like manner the web-footed order is an artificial one, including derivatives from different natural groups or types; and the same may be said of the order including the birds that have the legs long and naked above the tarsal joint. Derivatively the class of birds is most closely connected with the *Pterosaurian* order of cold-blooded air-breathers. In equivalency it is comparable rather with such a group than with the *Reptilia* in totality, or with the *Mammalia;* and hence the corresponding inferiority of value of the avian 'orders' to the subdivisions so-called of those larger classes.

In this arrangement the least organized are placed first. It agrees with most others in that the order is, beginning with the highest, raptorial birds, land birds, and water birds; but it does not appear to be so natural as that of Bonaparte's, as given below. The group *Insessores* of Vigors is here represented by the three orders *Cantores*, *Volitores*, and *Scansores*, which correspond to the orders *Passeres* and *Scansores* of Cuvier. This group, excluding the parrots, constitutes the prevalent type of living birds. It is far more numerously represented, both in species and individuals, than all the other orders put together; it presents as much variation of form and habits as they do, yet its members are so closely linked together from end to end that it is exceedingly difficult to separate them into natural subordinate groups. It is, moreover, sharply defined from the other orders, and these orders are themselves well marked off one from the other. Thus the insessorial birds form a central group, around which the others may be arranged at more or less distant intervals. No group has been more difficult to classify than this, and hence we find that it is with reference to it that there exists the greatest difference of opinion. The circular mode of arrangement derived much of its support partly from the homogeneousness of this group, and partly from the fact that birds of different types present corresponding modifications in a few external characters, which characters are most readily seized by the naturalist, and are due to, or at any rate correlated with, habits and habitat; while the more important typical characters are less easily detected. Many illustrations of this could be cited; but we can only mention one or two. In all large islands where carnivorous animals are neither abundant nor formidable, there is a remarkable prevalence of birds with strong legs and short wings, as, for instance, in New Zealand, Australia, and the Mascarene islands; and in many such places the introduction of the dog, cat, rat, or pig seems to have had a marked influence in reducing the numbers of such birds. In some geographical areas we may notice that certain external characters prevail throughout all the birds, although such characters are frequently not characteristic of the families to which many of the species belong. For instance, there is an extraordinary predominance of the colour red in the eastern half of the Malayan Archipelago, where even the *Psittacidæ* are red, with little or no green about them, although green is the prevailing tint in all the members of this family which live on other parts of the globe. A phenomenon of a similar nature is observable in the birds of the Azores. Most of the species are the same as occur on the neighbouring part of the European continent; and yet there is said to be a decided tendency among them to have darker plumage, shorter legs, and stronger bills than their continental representatives. In these instances the characters are spread amongst the individuals living on a certain area; and the variations are for the most part so slight that they do not give rise to errors of classification. But the same correlation of a set of external characters with surrounding conditions is more noticeable in birds having similar habits and habitats; as, for instance, in the swallows (*Hirundinidæ*) and swifts (*Cypselidæ*); in the creepers and woodpeckers; and in many others, some of which are indicated in other parts of this article. These analogous groups are the stumbling-blocks of classifiers, and they always will be so long as external characters are employed, without being checked by those derived from the internal organization. As a further illustration of the correlation of habits, habitat, and external features, we find that when a species has dissimilar habits from most other species of the same type, it also differs from them in what are considered to be important external characters; this is exemplified by the *Strigops* amongst parrots [PSITTACIDÆ, E. C. S.], and the water-ouzel among thrushes. We do not wish it to be inferred that habits and external characters are of little value in classifications, but that great caution should be used in relying solely upon them; and all species founded upon a single character, or upon a single dead specimen, should be regarded with suspicion.

That excellent results may be obtained from a consideration of the habits and characters of the living bird is, we think, shown in Mr. Wallace's arrangement of the order *Passeres*. His remarks were published in 1856; but, if we mistake not, many of his suggestions have been more or less adopted in that part of Professor Owen's classification which relates to the same group. His conclusions, moreover, generally harmonize with the improvements proposed by Eyton and Nitzsch before him, and Blanchard and others after him, on anatomical grounds; as also with what we consider to be the best features in Bonaparte's scheme. For these reasons we do not hesitate to give a full abstract of his paper, retaining in many places his own expressions. His observations refer more especially to Gray's arrangement in which the order *Passeres* is divided into the *Conirostres*, *Dentirostres*, *Fissirostres*, *Tenuirostres*, and *Scansores*. He condemns the plan as relying too much on the character of the beaks, and as thereby leading to unnatural combinations. The humming birds and sun birds are placed together, but should be widely separated, since their contiguity is based upon a resemblance in analogous not relative characters. The similarity in size, in the prevalence of lustrous colours, and in the slenderness of the bill, ought not to overbalance the most important structural differences. The hummers have excessively long wings, and extremely small feet, the toes being at the same time more or less united. The locomotion is exclusively aërial, the feet only being employed for purposes of support. The sun birds (*Cinnyridæ*) and their allies the *Cærebidæ* have long legs and toes, the hind toe being especially long and powerful; and hence they are able to hop and perch. Their wings are short, round, and not adapted for powerful or long continued flight. The tail is short and even. The tongue is short, flat, and not extensible in some genera, such as *Dicæum*, *Cinnyris*, and all the *Cærebidæ;* while in a few only, as in *Anthreptes* and *Arachnothera*, is it tubular and extensile. There is, therefore, no general agreement of structure, except that of an elongate and slender bill, which is not an important character. The *Conirostres* and *Dentirostres* are not natural groups, because they are based too much upon a single character, and too little on general structure. The association of hornbills with crows, and the separation of larks from wagtails, he considers to be erroneous.

The *Fissirostres* are those passerine birds whose feet are adapted solely for a state of rest—all motion being performed by the wing. With very rare exceptions they never move the slightest distance by means of their feet, a character which distinguishes them from all other *Passeres*, which either hop, climb, or walk incessantly. In this group there is every form of bill. The external characters are very short and weak legs, long or powerful wings, and a wide gape. Their habit is to sit motionless watching for their prey, to dart after it and seize it upon the wing, and to return to their original position to swallow it.

The Trogons and Kingfishers present these peculiarities in the greatest perfection. The Trogons are sometimes placed among the *Scansores* on account of the $\frac{2}{2}$-toed foot; but this form of foot does not affect their habits since the toes are connected at their base with a broad sole, which affords a firm base to stand upon. The position of the toes alone is of little importance, so long as the habits are not different. The Trogons do not climb. In South America they feed principally upon fruit. They take their station on a bare branch about the middle, and having fixed their attention on some fruit, dart at it, seize it dexterously on the wing, and return to their original seat. The Bee-eaters and Jacamars should come somewhere between the Kingfishers and Trogons, and the *Prionitidæ* should form part of the same group. All have similar habits. The *Coraciadæ* follow next. They were for long misplaced amongst the strong legged crows and grackles, whereas the short legs, wide gape, insect food captured on the wing, the nest in holes of trees or in the earth, and the colour and form of the eggs, all bring them in close relation to the bee-eaters, motmots, and kingfishers. The structure of the skeletons confirms this result. Next come the *Capitonidæ*, which have often been placed among the climbers on account of the two-two toed arrangement of the feet. They are sedentary birds with habits analogous to the bee-eaters, &c. Some, like *Tamatia*, frequent the gloomiest and thickest parts of the forest, where they sit motionless on some low branch, and thence take short flights for insects. Others, like *Monasa* and *Chelidoptera*, almost vie with the swallows in the litheness and celerity of their movements. They frequent more open situations, frequently sit on the branches of dead trees, and take longer flights. They build their nests in banks. The Swallows and Goatsuckers present the highest development of this type, but are distinctly separable from the preceding families. They are pre-eminently insect-catchers; their gape is of extraordinary proportions, their feet remarkably short, and their wings long and powerful. But there is a hiatus even between these two families. The swallows are considered to be the extreme term of the fissirostral series. Their small size, powerful flight, and compact plumage, added to their strongly grasping feet, sufficiently mark them off from the others. The *Caprimulgidæ* come nearer the *Trogonidæ*, as indicated by their average size, excessively thin skin, mass of downy plumage, general form, nature of food, and mode of capturing it. The structure of the feet is the most important objection to this view, but stronger objections may be raised against the swallows and *Caprimulgidæ* being placed in any other group. The *Eurylaimidæ* are generally placed amongst the *Fissirostres*, but Wallace believes they are true *Passeres* allied to *Cotinga* and *Querula*. The *Eurylaimus javanicus* and *Cymbirhynchus macrorhynchus* feed like perching birds, hopping about the branches of trees and picking off the fruit. Their legs are of moderate length, their toes strong, and the hind toe large and powerful, which is never the case in true *Fissirostres*. It is this peculiar conformation of the feet which affects the whole character and habits of the birds, which habits are not fissirostral. The circumstance of partial syndactyly is of little classificatory importance. The Manakins and *Rupicolæ* have united toes, and have been placed amongst *Fissirostres* on that account; but they are fruit-eaters, use their feet actively, possess a strong skin and firm set plumage, and have peculiarities which should rank them amongst the perchers, not amongst the *Fissirostres*. The *Calyptomena viridis* is essentially a chatterer. The Todies also have been placed in this group; but their moderately long and slender legs, short rounded wings, and incessant use of their feet for locomotive purposes, show that they ought to be placed alongside such fly-catchers as *Todirostrum* and *Megalophus*. They are active little birds, hopping, perching, and flying after insects in every possible place and position, in which they differ widely from *Fissirostres*; but they agree with them in nidificating in holes in banks of streams. This one character should not override the others which decidedly show that they do not belong to the *Fissirostres*. The Hornbills are considered to be Fissirostral birds. Their very short legs, and united toes with a broad flat sole, are exactly similar to those of the kingfishers. They are, in the Indian archipelago, entirely frugivorous; and it is curious to observe how their structure modifies their mode of feeding. They cannot dart after the fruit like the trogons; they cannot even fly rapidly from branch to branch, picking a fruit here and a fruit there; neither have they the agility to alight on the more slender branches like the barbets; but they alight heavily on a thick branch, and then, looking cautiously round them, pick off the fruits within reach and jerk them down their throats like the toucans. When all has been gathered within reach they move sideways along the branch by short jumps, or rather a kind of shuffle, and the smaller species even hop across the branches, when they again gather all within reach. When one branch is done they fly to another tree. Their short legs and syndactyle feet remove them from the Toucans. Their wings are as powerful as those of toucans are weak, but their great weight prevents rapid flight. As they fly they produce a loud sound, which is said to be in some species even louder than that made by the great muscovy duck. Although conirostral they are far removed from the crows. They appear to come nearest the Kingfisher. Eyton arrived at similar conclusions from a consideration of the osseous structure. The *Trochilidæ* are also assigned to this tribe. They have minimized feet and maximized wings. They surpass the swallows in power of flight. Their feet resemble those of *Dendrochelidon*, and the long variously curved bill and extensile tongue give them the same facilities in obtaining food as the short bill and wide gape of the other. They are believed to be purely insectivorous, since the stomachs are always filled with flower-frequenting *Coleoptera*; but they may obtain some nourishment from the nectar. Their thick firm muscles imply an animal rather than a vegetable diet; as also do their short stomach and intestines. Moreover, certain species never frequent flowers. All the species of *Phaethornis* occur among low shrubs where they search amongst the leaves for insects while they sustain themselves almost motionless in the air, with their body erect and their bills pointing upwards. They do not frequent the flowery glades, but the gloomy flowerless jungles. Some species hunt insects in the air like true fissirostral birds. They emerge from their retreats in the evening, dart after the minute insects, and return after each circuit to the edge of the forest, where they remain balanced for a moment preparatory to making another dart amongst the trees. At other times they will sit on the topmost twig of a dead tree, and after making short circuits return to it like the jacamar and puff-birds. It may be mentioned also that the young accept flies, but reject honey. Mr. Wallace had two newly hatched which he tried to feed with syrup made with honey and water; but they did not like it and sputtered it out in disgust. He then tried them with some minute flies. On dropping an insect into the mouth of one it immediately closed the beak, swallowed the morsel with an effort, and opened the mouth for another. In this way each bird disposed of fifteen or twenty flies. Their beaks were very short, triangular, and very broad at the base, or like a swallow's beak slightly lengthened. Humming-birds are, he conceives, an extreme and peculiar development of the Hirundine form of *Fissirostres*. The skin, which in the tribe is generally thin and tender, is in the swallows comparatively thick and strong; and in the hummers is perhaps stronger in proportion to their size than in any other birds. The structure of the tongue may be considered as an objection to this view, but he urges that this character should not outweigh the others; and he cites examples in which the tongue differs widely in two families acknowledged to be closely allied, such as the cuckoos and toucans. The *Picidæ* and *Dendrocolaptidæ* on the other hand afford an example of similarity of tongue in families whose general structure is different. The nidification is the most important difficulty; but he remarks that we should expect a deviation in this respect in such aërial birds as *Trochilidæ*. His arrangement of the *Fissirostres* is as follows:—

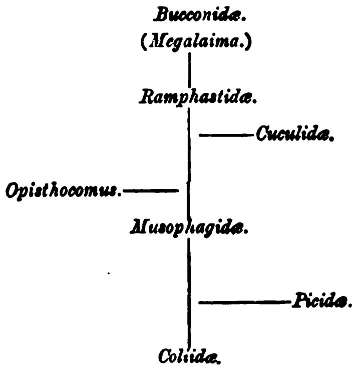


The spaces are intended to show the relative amount of affinity existing between any two groups. The gaps represent to a certain extent the result of the extinction of species. Thus he remarks if the space between the kingfishers and hornbills were filled up by a natural succession of families, we can see that the change must have been to heavier, larger, and longer billed birds, and traces of such a change occur in passing from the jacamar to the kingfisher. Again, in passing from the goat-suckers to the swallows, the change is to smaller, stronger winged, thicker skinned, and lighter coloured birds, which if carried on would lead to the hummers. Again, as the change from the jacamars to the rollers is to stronger legged birds which do not feed solely on the wing, but partially on the ground, so the same change would lead to *Passeres*. The *Coraciadæ*, therefore, are either an extreme Passerine form of the tribe, or else form a transition by direct affinity to the *Passeres*. It will be noticed that Mr. Wallace speaks of the *Hirundinidæ*, which evidently include both the swallows and the swifts; but we think his position would be improved if the swallows were excluded and *Hirundinidæ* were replaced by the term *Cypselidæ*.

The *Picidæ*, *Psittacidæ*, *Cuculidæ*, and *Ramphastidæ* are generally admitted to be *Scansores*. They are taken as affording the real basis for ascertaining the character of the order. There is no general resemblance in the form of the beak, so that the characters must be sought in some other part. The wings are generally short, rounded, and very weak, and not adapted for rapid or long-sustained flight. The legs are large, powerful, and of peculiar conformation. They are mainly antithetical to those of the *Fissirostres*. The toes are long, and the outer toe is either turned completely backwards or nearly at right angles to the others. This toe is often the largest of all, while the true hind toe is always small, and sometimes altogether wanting. It is this structure which distinguishes them from all the short winged and strong footed *Passeres*. The habits resulting from this conformation are also characteristic. They are truly arboreal, rarely descending voluntarily to the ground. They use their wings only in flying from tree to tree, and they obtain their food in or upon trees. Their motions are either climbing or a succession of rapid hops producing an appearance of climbing. The woodpecker runs up the vertical trunk, and with the aid of the tail and beak seeks his food beneath the bark. The parrot climbs after the fruit, which alone he feeds on. The cuckoo seeks insects on the leaves and branches. The toucans hop actively about the tops of lofty trees after fruit. Although these families should come near together, they are separated from one another by wide chasms. The *Bucconidæ* should be rejected from the *Scansores*. Though they cling against and peck at trees, their general structure differs from that of woodpeckers. In their feet, wings, and general form they more resemble toucans. The texture of the feathers, their broad, angular, and weak skulls, indicate their relation with the toucans and difference from the woodpeckers. The bill has a different type of form, reminding one of a cuckoo's. They hop and cling, but never climb. The *Dendrocolaptidæ* are generally associated with the woodpeckers on account of their climbing habits, their rigid tails, their insect diet, and their manner of obtaining it from the trunks and branches of trees. The differences are a short bill, a horny, non-extensile tongue, and a very differently constructed foot. The characteristic form of the foot in the *Certhiadæ* and *Dendrocolaptidæ* is to have the toes placed normally, three forward and one backward, and to have all the forward toes connected together at their bases, particularly the outer toe, which is generally larger than the inner, and often connected to the middle toe as far as the second joint. The result is that the forward toes do not spread much, but form one line of support opposed to the hind toe. The hind toe is also remarkably long and powerful, and armed with an equally powerful claw. This peculiar structure has been arrived at through the most nearly allied families of *Passeres*. Passing from the wagtails through the *Anabatidæ* to *Dendrocolaptidæ*, we find the outer toe gradually more and more united to the middle one, and the hind toe becoming gradually larger and more developed; so that we see that modification of the normal three-one toed foot which is adapted for climbing. In the woodpecker, however, the outer toe is always turned completely backwards, and is therefore quite free from the middle toe. The true hind toe is also invariably small and weak, and of so little importance that in several species of woodpeckers it is altogether wanting without at all diminishing the power of climbing. It is an extreme modification of the scansorial form adapted for true climbing. The toes are all more powerful, the claws much stronger, the outer toe longer, and the hind toe smaller. If, therefore, the structure of the foot in the cuckoos and touracos, where the outer toe can be placed either forward or backward and the hind toe remains moderately developed, is the link between the two-two toed and the three-one toed forms, then it follows that of all two-two toed feet the woodpecker's is most removed from the three-one toed; and of all three-one toed the creeper's is the furthest removed from the two-two toed; and hence the feet of the creeper and the woodpecker are farthest removed from each other. When it is further considered that the structure of the climbing tail is totally dissimilar in the two cases, we at once see that the creepers should be widely separated from the *Scansores*.

The *Musophagidæ* are considered to be true Scansorial forms. They have short, rounded, and weak wings like the cuckoos and toucans, their legs are very strong, the outer toe is long and versatile, but rather less so than in the cuckoos, and the hind toe is short. In their habits and plumage they resemble the toucans and barbets, while in their short crests they are similar to the woodpeckers. They nidificate in holes in trees, and in their general internal structure appear to correspond with the Scansorial type. Swainson placed them between the *Fringillidæ* and *Bucerotidæ*. The former have well-formed passerine feet, the hind toe is always well developed, and the outer toe is never so long as the middle one. Their uniformly small size and generally powerful wings do not appear to be consistent with a close affinity with the *Musophagidæ*. The hornbills are still further removed. He thinks Swainson must have been misled by his blind belief in numerical and circular arrangements. The correctness of this system of classification he refutes on two grounds. First, the existing species form a small proportion only of the total number that have existed; so that for every living genus there are probably many extinct ones which ought to find a place in a natural classification; but in Swainson's scheme there are very few gaps to represent the places of the absent forms. Secondly, by the system of definite numbers the genera are limited to 25 in each family, so that if 25 genera are known, it is assumed that there are no extinct forms in that family. Mr. Wallace places *Opisthocomus cristatus* between the Touracos and the *Cuculidæ*. It is very abundant on the banks of the Amazon. It frequents low bushes on the river's edge, and never alights on the ground. This, combined with the absence of a gizzard, decides that it is not gallinaceous. Its general appearance, flight, and habits suggest that it is a gigantic cuckoo. Its long crest remarkably resembles that of the genus *Diplopterus*, several species of which occur in the same district, and they all have the habit of throwing it up when alarmed in precisely the same way. There is no versatile outer toe on its feet, which is an objection to placing it among the *Scansores*. But there is a genus of *Musophagidæ* (*Schizorrhis*) which also has all the toes turned forwards. The short wings, weak, heavy flight, strong legs, long toes, and the character of the plumage, indicate this to be its true position, while its peculiar food and internal structure show that it is isolated, and not a member of any known family.

The *Coliidæ* are more like parrots than any other birds. Their habits have many resemblances to those of parrots, as will be seen by perusing the account under MUSOPHAGIDÆ, E. C. vol. iii. col. 997. They are, like parrots, remarkably fleshy, and heavy in proportion to their apparent size. They weigh twice as much as most other birds of apparently the same size, owing to their feathers being so short, and so closely applied against the body. Their bill resembles the parrot's in the inequality of the mandibles. The feet are peculiar, the hind toe being small, and capable of being turned forward. The tongue is cartilaginous and flat.



The rest of the *Passeres*, he thinks, forms a natural group which he would call normal or typical *Passeres*. It comprises about 35 families, and between 3000 and 4000 species, or at least half of all known birds. They are too intimately allied to be broken up into various groups. They all have normal or three-one toed feet, which are never so weak or short as to be unadapted for progression. The bill is always moderate in size and form, and in the few cases where it is peculiarly modified, as in *Dendrocolaptes*, other species in the same family possess the normal form. There is also a remarkable moderation in size, as well as great uniformity in texture of plumage, form, and habits. There are no isolated families, and hence there is much disagreement as to their limits, since one family blends into others. His diagram of the Scansorial affinity is given on the previous page.

One of the defects in this arrangement is that the *Psittacidæ* are included amongst the *Scansores;* but Mr. Wallace himself now admits that the *Psittacidæ* should form a distinct order. [PSITTACIDÆ, E. C. S.].

Many of the views proposed by Mr. Wallace seem to have been already embodied in Prince Bonaparte's classification, published in 1854. ('Annales des Sciences Naturelles: Zoologie,' 4th Series, vol. i. p. 105-152.) We can only give a tabular outline of this classification. In the original it is arranged lineally, but we have ventured to arrange some of the groups in parallel series, in order to bring out more prominently the relations between analogous families.

He recognises twelve orders, which are thus arranged :—

Orders. ALTRICES.
1. Psittaci.
2. Accipitres.
3. Passeres.
Tribe 1. Oscines.
Tribe 2. Volucres.
Cohort 1. Zygodactyli.
Cohort 2. Anisodactyli.
4. Inepti.
5. Columbidæ.
Tribe 1. Pleiodi.
Tribe 2. Gyrantes.
6. Herodiones.
Tribe 1. Grues.
Tribe 2. Ciconiæ.
7. Gaviæ.
Tribe 1. Totipalmi.
Tribe 2. Longipennes.
Tribe 3. Urinatores.
8. Ptilopteri.

PRÆCOCES.
9. Gallinæ.
Tribe 1. Passeraceæ.
Tribe 2. Gallinaceæ.
1. Craces.
2. Galli.
3. Perdices.
10. Grallæ.
Tribe 1. Cursores.
Tribe 2. Alectorides.
11. Anseres.
12. Struthiones.

SYNOPSIS OF FAMILIES.

The order *Psittaci* embraces :—

Psittacidæ.
Microglossidæ.
Trichoglossidæ.
Strigopidæ.
300 species.

The order *Accipitres* embraces :—

Vulturidæ.
Gypaetidæ.
Gypohieracidæ.
Falconidæ.
Gypogeranidæ.
Strigidæ.
440 species.

The order *Passeres* embraces :—

OSCINES.
Stirps 1. Cultrirostres.
Corvidæ.
Garrulidæ.
Sturnidæ.
Icteridæ.
Stirps 2. Conirostres.
Ploceidæ.
Fringillidæ.
Stirps 3. Subulirostres.
Turdidæ.
Maluridæ.
Timaliidæ.
Troglodytidæ.
Certhiidæ.
Paridæ.
Cinclidæ.
Motacillidæ.
Alaudidæ.
Stirps 4. Curvirostres.
Epimachidæ.
Paradiseidæ.
Glaucopidæ.
Meliphagidæ.
Arachnotheridæ

VOLUCRES.
Cohort 1.
Zygodactyli.
Stirps 7. Amphiboli.
Ramphastidæ.
Cuculidæ.
Stirps 8. Scansores.
Picidæ.
Stirps 9. Barbati.
Bucconidæ.
Capitonidæ.
Leptosomidæ.
Galbulidæ.
Stirps 10. Heterodactyli
Trogonidæ.
625 species.

Cohort 2.
Anisodactyli.
Stirps 11. Frugivori.
Bucerotidæ.
Musophagidæ.
Opisthocomidæ.
Coliidæ.
Phytotomidæ.
Stirps 12. Formicivori.
Menuridæ.
Myiotheridæ.
Anabatidæ.
Dendrocolaptidæ.
Stirps 13. Muscivori.
Todidæ.
Cotingidæ.
Pipridæ.
Eurylaimidæ.
Stirps 14. Callocoraces.
Pittidæ.
Coraciidæ.
Prionitidæ.
Stirps 15. Gressorii.
Meropidæ.

OSCINES, *continued.*
Phyllornithidæ.
Nectariniidæ.
Drepanidæ.
Dicæidæ.
Cœrebidæ.
Stirps 5. Dentirostres.
Laniidæ.
Artamidæ.
Oriolidæ.
Edoliidæ.
Ampelidæ.
Muscicapidæ.
Tanagridæ.
Stirps 6. Fissirostres.
Hirundinidæ.
3500 species.

VOLUCRES, *continued.*
Alcedinidæ.
Stirps 16. Tenuirostres.
Upupidæ.
Promeropidæ.
Stirps 17. Suspensi.
Trochilidæ.
Stirps 18. Hiantes.
Cypselidæ.
Stirps 19. Insidentes.
Steatornidæ.
Caprimulgidæ.
1775 specie

The order *Inepti* has one family only, viz. :—

Dididæ, with 5 species.

The order *Columbæ* embraces :—

Tribe 1. Pleiodi.
Didunculidæ.
Tribe 2. Gyrantes.
Treronidæ.
Columbidæ.
Calliœnadidæ.
Gouridæ.
220 species.

The order *Herodiones* embraces :—

Tribe 1. Grues.
Phœnicopteridæ.
Gruidæ.
Tribe 2. Ciconiæ.
Dromadidæ.
Ciconiidæ.
Ardeidæ.
Cancromidæ.
Plataleidæ.
Tantalidæ.
173 species.

The order *Gaviæ* comprises :—

Tribe 1. Totipalmi.
Pelecanidæ.
Tachypetidæ.
Plotidæ.
Phætonidæ.
Tribe 2. Longipennes.
Procellariidæ.
Laridæ.
Chionidæ.
Tribe 3. Urinatores.
Alcidæ.
Colymbidæ.
Podicipidæ.
325 species.

The order *Ptilopteri* comprises only

Spheniscidæ. 15 species.

The order *Gallinæ* includes :—

Tribe 1. Passeraceæ.
Mesitidæ.
Megapodiidæ.
Rollulidæ.
Numididæ.
Tribe 2. Gallinaceæ.
Craces.
Meleagridæ.
Cracidæ.
Penelopidæ.
Galli.
Pavonidæ.
Phasianidæ.
Perdices.
Thinocoridæ.
Pteroclidæ.
Tetraoninæ.
Perdicidæ.
Crypturidæ.
320 species.

The order *Grallæ* is formed by :—

Tribe 1. Cursores.
Otidæ.
Charadriidæ.
Hæmatopidæ.
Recurvirostridæ.
Phalaropodidæ.
Scolopacidæ.

Tribe 2. Alectorides.
Parridæ.
Rallidæ.
400 species.

The order *Anseres* contains :—

Anatidæ.
Mergidæ.
200 species.

The order *Struthiones* embraces :—

Struthionidæ.
Dinornithidæ.
Apterygidæ.
12 species.

Altogether, he recognises 131 families, 2120 genera, and 8300 species. Each order averages 11 families ; each family averages 15¼ genera, and about 60 species ; and each genus averages nearly 4 species. In running one's eye over the figures, we are struck by the great paucity of specific forms in the families of the groups which follow after the *Passeres*. Thus in the first three orders there are on the average 88 species per family ; and in all the remainder there is an average of only 32 per family, or if the *Anseres* be excluded, there are only 29 species per family. The specific numbers in the above totals refer to the year 1858 ; there have been many additions since.

As an example of a classification in which the main characters are drawn from the osseous structure, we would cite that proposed by Professor Huxley, 'Proceedings of the Zoological Society, 1867, p. 415—472.' He points out that while birds differ widely from reptiles, still the connection between them is so much closer than between birds and any other class as to justify their association into one primary group, to which he gives the name *Sauropsida*. The class *Aves* is arranged in three orders, viz., the *Saururæ*, *Ratitæ*, *Carinatæ*.

The order *Saururæ* comprises *Archæopteryx* only, and is characterised by the following features. (1) The metacarpal bones are well developed and not anchylosed. (2) The caudal vertebræ are numerous and large, so that the caudal region of the spine is longer than the body, whereas it is shorter in all other birds. (3) The furculum is complete and strong ; and the foot is very passerine in structure.

The order *Ratitæ* comprises the Struthious birds. Its principal features are as follows. (1) The sternum has no crest, and is ossified from lateral and paired centres. (2) The long axes of adjacent parts of the scapula and coracoid are parallel or identical. There are no acromial or clavicular processes ; or, if present, they consist of inconspicuous tubercles only. (3) The posterior ends of the palatines and the anterior ends of the pterygoids are imperfectly or not at all articulated with the basi-sphenoidal rostrum ; being usually separated from it, and supported, by the broad, cleft, hinder end of the vomer. (4) The basipterygoid processes are strong, and arise from the body of the basisphenoid, not from the rostrum. The articulation is by means of facets, which are situated nearer the posterior than the anterior ends of the lower edges of the pterygoid bones. (5) The upper or proximal articular head of the quadrate bone is not divided into two distinct facets. (6) Barbs of feathers disconnected. (7) There is no larynx, and the diaphragm is well developed. Five subordinate groups are recognised. *Struthio* is the type of one ; *Rhea* of a second ; *Casuarius* and *Dromaius* of a third ; *Dinornis* of a fourth ; and *Apteryx* of a fifth.

The order *Carinatæ* embraces all the living birds but the *Ratitæ*. It is thus characterised. (1) The sternum has a keel, and is ossified from a median centre in that keel, as well as from lateral paired centres. (2) The long axes of the adjacent parts of the scapula and coracoid are inclined towards each other at an acute or slightly obtuse angle, and are never even approximately identical or parallel. (3) The vomer is comparatively small, and allows the palatines and pterygoids to directly articulate with the basisphenoidal rostrum.

This order he proposes to group into the four sub-orders, *Dromæognathæ*, *Schizognathæ*, *Desmognathæ*, *Aegithognathæ*.

The sub-order *Dromæognathæ* is represented by *Tinamus* only. The vomer is very broad ; it unites in front with the broad maxillo-palatine bones, while behind it receives the posterior extremities of the palatines and the anterior ends of the pterygoids, which are consequently prevented from articulating with the basisphenoidal rostrum. The basisphenoid processes spring from the body of the sphenoid, not from its rostrum, and articulate with the pterygoids very near the distal or outer ends of the latter bones. The quadrate bone has a single head. It contains but one family—the *Tinamidæ*.

The sub-order *Schizognathæ* is equivalent to the *Gallinæ*, *Grallæ*, and *Natatores* of Cuvier. The vomer is sometimes large, sometimes small, but always tapers to a point anteriorly, while posteriorly it embraces the basisphenoidal rostrum between the palatines. The palatines and pterygoids are directly articulated with one another and with the basisphenoidal rostrum, and are not supported by the divergent posterior ends of the vomer. The maxillo-palatines are usually elongated and lamellar ; they pass inwards over the anterior processes of the palatine bones, and then, bending backwards along the inner edge of the palatines, leave a broader or a narrower fissure between themselves and the vomer, and do not unite with it or with one another. It comprises six groups of allied families ; viz., (1) *Charadriomorphæ*, or the pluvialine group. (2) *Geranomorphæ*, or the gruine group, of which the cranes and rails are the types. (3) *Cecomorphæ*, or the gull group. It contains the *Laridæ*, *Procellariidæ*, *Colymbidæ*, and *Alcidæ*. (4) *Spheniscomorphæ*, or the penguin group. It contains the single family, *Aptenodytidæ*, or the *Squamipennes* of most authors. (5) *Alectoromorphæ*, or the galline group. It contains the families, *Turnicidæ*, *Phasianidæ*, *Pteroclidæ*, *Megapodidæ*, and *Cracidæ*, or the *Gallinæ* of most authors, excluding the pigeons and *Tinamidæ*. (6) *Peristeromorphæ*, or the columbine group.

The sub-order *Desmognathæ* embraces all the members of Cuvier's *Grallæ* and *Natatores* which are not Schizognathous, the *Accipitres*, *Scansores*, most of the *Fissirostres*, all *Syndactyli*, and *Upupa*. In it the vomer is abortive or small. When present it is slender and attenuated anteriorly. The maxillo-palatines are united across the middle line, either directly or by means of ossifications in the nasal septum. The posterior ends of the palatines and the anterior ends of the pterygoids articulate directly with the rostrum. Seven groups of families are recognised. (1) *Chenomorphæ*, or the Anserine group. (2) *Amphimorphæ*. This appears to embrace the genus *Phœnicopterus* only, which occupies a middle place between the *Chenomorphæ* and (3) *Pelargomorphæ*, or ciconine group. (4) *Dysporomorphæ*, or gannet group. (5) *Aetomorphæ*, or aquiline group. This is arranged in four minor divisions, viz., *Strigidæ*, *Cathartidæ*, *Gypaetidæ*, and *Gypogeranidæ*. The *Cathartidæ* includes the vultures of the New World ; the *Gypaetidæ* includes the vultures of the Old World, and all the diurnal birds of prey, except *Gypogeranus*, which is the only representative of the *Gypogeranidæ*. (6) *Psittacomorphæ*, or the psittacine group. (7) *Coccygomorphæ*, or the cuculine group. This also is arranged in four minor divisions as follows :—

a. First toe turned forwards as well as the others. *Coliidæ*.
b. Fourth toe temporarily or permanently turned backwards as well as the first. *Musophagidæ*, *Cuculidæ*, *Bucconidæ*, *Ramphastidæ*, *Capitonidæ*, *Galbulidæ*.
c. Second, third, and fourth toes turned forwards ; the first backwards. *Alcedinidæ*, *Bucerotidæ*, *Upupidæ*, *Meropidæ*, *Momotidæ*, *Coracidæ*.
d. First and second toes permanently turned backwards ; the third and fourth forwards. *Trogonidæ*.

The *Celeomorphæ*, or picine group, composed of the *Picidæ* and *Yungidæ*, is not definitely placed in any of the sub-orders. Professor Huxley conceives that it is an aberrant group of the *Ægithognathæ*, intermediate between the *Coracomorphæ* and *Coccygomorphæ*. He objects to the association of the *Psittacomorphæ*, *Coccygomorphæ*, and *Celeomorphæ* with the order *Scansores*, as being unnatural.

The sub-order *Ægithognathæ* has the vomer broad, abruptly truncated in front and deeply cleft behind, embracing the rostrum of the sphenoid between its forks. Palatines have produced postero-external angles. Maxillo-palatines are slender at their origin, and extend inwards and backwards obliquely over the palatines, ending beneath the vomer in expanded extremities which do not become united by bone, either with one another or with the vomer. The anterior part of the nasal septum is frequently ossified, and the interval between it and the premaxilla is filled up with spongy bone ; but no union occurs between this ossification and the vomer. Two minor groups are recognised : (1) *Cypselomorphæ*, or the cypseline group, which contains the *Trochilidæ*, *Cypselidæ*, and *Caprimulgidæ* ; (2) *Coracomorphæ*, or the passerine group, which nearly corresponds with the *Passeres* of Cuvier.

There is another classification based almost entirely upon osteological characters, which has been recently published. It is that of Mr. Eyton, as contained in his 'Osteologia Avium' (1859—1867). The following brief outline, borrowed from the

'Record of Zoological Literature' for 1867, will serve to indicate its principal features. There are thirteen orders, the names of which are prefixed by Roman numerals. I. RAPTORES.—(1) *Vulturidæ*, (2) *Falconidæ*, (3) *Strigidæ*. II. VOLITORES.—(1) *Trochilidæ*, (2) *Cypselidæ*. III. OMNIVORES.—(1) *Caprimulgidæ*, (2) *Trogonidæ*, (3) *Alcedinidæ*, (4) *Buceridæ*. IV. PREHENSORES.—(1) *Psittacidæ*, (2) *Ramphastidæ*. V. SCANSORES.—(1) *Picidæ*. VI. ERUCIVORES.—(1) *Cuculidæ*, (2) *Musophagidæ*. VII. INSESSORES.—(1) *Menuridæ*, (2) *Certhiidæ*, (3) *Meliphagidæ*, (4) *Paridæ*, (5) *Alaudidæ*, (6) *Motacillidæ*, (7) *Sylviidæ*, (8) *Muscicapidæ*, (9) *Ampelidæ*, (10) *Laniidæ*, (11) *Turdidæ*, (12) *Oriolidæ*, (13) *Sternidæ*, (14) *Fringillidæ*, (15) *Tanagridæ*, (16) *Corvidæ*. VIII. BIPOSITORES.—(1) *Columbidæ*, (2) *Dididæ*. IX. RASORES.—(1) *Tetraonidæ*, (2) *Phasianidæ*. X. CURSORES.—(1) *Struthionidæ*. XI. LITTORES.—(1) *Otidæ*, (2) *Charadriidæ*, (3) *Scolopacidæ*, (4) *Tringidæ*. XII. GRALLATORES.—(1) *Ardeidæ*, (2) *Rallidæ*. XIII. NATATORES.—(1) *Anatidæ*, (2) *Colymbidæ*, (3) *Alcidæ*, (4) *Pelicanidæ*, (5) *Laridæ*.

Classifications have also been proposed by Fitzinger, Lilljeborg, and others. In Lilljeborg's scheme irritability is regarded as the most distinguishing character in birds, and hence he places the lively, intelligent, bustling *Passeres* at the head of the class, and far ahead of the birds of prey, which are generally honoured with the post of the lords of the feathered world. He recognises the class *Aves* as divisible into three sub-classes, the *Insessores, Cursores*, and *Natatores*. The *Insessores* contains five orders, viz., *Passeres, Zygodactyli, Strisores, Accipitres*, and *Pullastræ*. The *Cursores* has three orders, the *Gallinæ, Brevipennes*, and *Grallæ;* and the *Natatores* comprises the four orders, *Lamellirostres, Steganopodes, Longipennes*, and *Pygopodes*.

We next enter upon that branch of our subject which relates to the geographical distribution of the feathered host, the members of which are pre-eminent for the facility with which they can move from place to place, in which respect they far excel man, whose mighty intellect and princely possessions have enabled him to dash along at the rate of 60 or 70 miles per hour, whereas the bird will accomplish a journey of many hundred miles twice as quick as man. Under such circumstances, we should hardly expect to find the limitation of groups to definite areas so marked in birds as in other animals. We know that they do travel from one region to another in obedience to some uncontrollable impulse which we cannot understand; that inland waders migrate periodically to the sea-shores; that the summer birds in high latitudes take up their winter residences in the middle latitudes; that the summer birds of temperate latitudes, such as England is in, wander away to sunnier climes, where our wintry frosts cannot touch them; and yet, notwithstanding this periodical vibration with a swing of hundreds of miles, birds are highly amenable to laws of geographical distribution. But the subject is so vast that it is quite beyond the power of a mere compiler adequately to grapple with it, or to bring it within the limits of the Procrustean bed allotted to us. In spite of ourselves, we find, "our language grows, and, like the tide, our work o'erflows." If we restrict ourselves to a general view of the subject, we overlook those minor details, the truth and universality of which impart to generalizations a vividness of meaning which flashes across the mind of all who are acquainted with the details; whereas if we descend to minute circumstantialities we only lift up a corner of the curtain. To a person just entering upon the study we should recommend him to collect the details for himself, and as a clue to the bibliography he cannot take a better guide than the 'Record of Zoological Literature,' edited by Dr. Günther, in which the literature of each year is arranged under the head of what we venture to call "the Sclaterian regions." This term requires explanation, and we proceed to give it. These regions are proposed by Dr. Sclater as representing the principal divisions of the globe when the distribution of birds is taken as the basis. He recognises the Old and New Worlds as the primary divisions, there being numerous families peculiar to each, and very few genera in common. The following table is a list of the more important peculiar families:—

NEW WORLD, or Neogean Area.	OLD WORLD, or Palæogean Area.
Todidæ.	Coraciidæ.
Momotidæ.	Eurylaimidæ.
Bucconidæ.	Meropidæ.
Galbulidæ.	Upupidæ.
Trochilidæ.	Bucerotidæ.
Icteridæ.	Sturnidæ.
Cœrebidæ.	Paradiseidæ.
Formicariidæ.	Meliphagidæ.
Dendrocolaptidæ.	Promeropidæ.
Tyrannidæ.	Muscicapidæ.
Cotingidæ.	Musophagidæ.
Ramphastidæ.	Coliidæ.
Opisthocomidæ.	Megapodidæ.
Cracidæ.	Pteroclidæ.
Tinamidæ.	Phasianidæ.
Meleagrinæ.	Perdicinæ.
Odontophorinæ.	

The total area of dry land is estimated at 45,000,000 square miles, and the number of species at 7500; so that on the average there is one species for every 6000 square miles. The Palæogean area contains 33,000,000 square miles of dry land, and 4500 species, or an average of one species for every 7300 square miles. The Neogean area comprises 12,000,000 square miles, and 3000 species, which gives an average of one species per 4000 square miles.

The Palæogean area is divided into four regions, named respectively the Palæarctic; the Æthiopian, or western Palæotropical; the Indian, or Middle Palæotropical; and the Australian or eastern Palæotropical. The Palæarctic region has an approximate area of 14,000,000 square miles, and 650 species, or one species per 21,000 square miles. It embraces Africa north of the Atlas, Europe, Asia Minor, Persia, and Asia generally north of the Himalayan range, upper part of the Himalayan range? northern China, Japan, and the Aleutian Islands. Its characteristic forms are—*Sylvia, Luscinia, Erythacus, Accentor, Regulus, Podoces, Fregilus, Garrulus, Emberiza, Coccothraustes, Tetrao*. The number of European species known in 1858 is given in the table, col. 125. The Æthiopian region has an approximate area of 12 million square miles, and 1250 species, or one species per 9600 square miles. It embraces Africa and its islands south of the Atlas, and probably a large portion of Arabia. Its characteristic forms are—*Gypogeranus, Helotarsus, Polyboroides, Gypohierax, Melierax, Macrodipteryx, Irrisor, Fregilupus, Bucorvus, Apaloderma, Parisoma, Macronyx, Lioptilus, Sericolius, Phyllastrephus, Laniotardus, Vidua, Juida, Buphago, Verreauxea, Læmodon, Indicator, Musophaga, Colius, Poiocephalus, Numida, Phasidus, Struthio, Balæniceps, Scopus*. Madagascar is characterised by — *Euryceros, Falculia, Oriolia, Philipitta, Brachypteracias, Aletornis, Bernieria, Hartlaubius, Artamia, Vanga, Coua, Leptosomus, Vigorsia, Mesites*, and *Biensis*. The number of species resident in West Africa as given in Hartlaub's 'System der Ornithologie West Africa's,' and in north-east Africa, as given by Dr. Heuglin, will be seen in the table in col. 125. The Indian region has an area of nearly 4,000,000 square miles, and about 1500 species, or one species per 2600 square miles. It comprises India and Asia generally south of the Himalayas, Ceylon, Burmah, Malacca, South China, Philippines, Borneo, Java, Sumatra, and adjacent islands. Its characteristic genera are — *Harpactes, Collocalia, Calyptomena, Eurylaimus, Buceros, Garrulax, Liothrix, Malacocercus, Pitta, Timalia, Pycnonotus, Phyllornis, Pericrocotus, Analcipus, Acridotheres, Gracula, Sasia, Megalæma, Phænicophaus, Dasylophus, Palæornis, Pavo, Ceriornis, Polyplectron, Argus, Euplocamus, Rollulus, Casuarius*. A summary of the birds of China, as based on Mr. Swinhoe's researches, will be found in the table in col. 125. The Australian region has an area of perhaps 3,000,000 square miles, and probably 1000 species, or one species to every 3000 square miles. It embraces Papua and the adjacent islands, Australia, Tasmania, and Pacific Islands. The characteristic forms are in the case of (1) Australia; *Ægotheles, Falcunculus, Colluricincla, Grallina, Gymnorhina, Strepera, Cinclosoma, Menura, Psophodes, Malurus, Sericornis, Ephthianura, Pardalotus, Chlamydera, Ptilonorhynchus, Struthidea, Licmetis, Calyptorhynchus, Platycercus, Euphema, Calopsitta, Climacteris, Scythrops, Myzantha, Talegalla, Leipoa, Pedicnemis, Dromaius, Cladorhynchus, Tribonyx, Cereopsis, Anseranas, Biziura*. (2) Papua, *Sericulus, Melanopyrrhus, Ptiladela, Edoliosoma, Peltops, Rectes, Manucodia, Gymnocorvus, Astrapia, Paradisea, Epimachus, Nasiterna, Charmosyna, Cyclopsitta, Goura*, &c. (3) New Zealand; *Neomorpha, Prosthemadera, Anthornis, Acanthisitta, Mohoa, Certhipacus, Turnagra, Aplonis, Creadion, Nestor, Strigops, Apteryx, Ocydromus*. (4) Pacific Islands; *Moho, Hemignathus, Drepanis, Pomarea, Metabolus, Sturnoides, Leptornis, Tatare, Loxops, Coriphilus, Ptilonopus*. A summary of the Australian species, as given in Gould's 'Birds of Australia,' is incorporated in the table in col. 125. In his later work, entitled, 'Handbook to the Birds of Australia,' 2 vols., 1865, 670 species are described.

The Neogean area is divided into two regions, viz., the Nearctic, or North American, and the Neotropical, or South

American. The Nearctic comprises an area of perhaps 6,500,000 square miles, and contains, according to calculation, 666 species, or one species per 9000 square miles. It extends as far south as the centre of Mexico. Its characteristic forms are :—*Trochilus, Sialia, Toxostoma, Icteria, Vireo, Mniotilta, Chamæa, Certhia, Sitta, Neocorys, Calamospiza, Zonotrichia, Picicorvus, Gymnocitta, Meleagris.* The Neotropical region is formed by the West India islands, Southern Mexico, Central America, South America, Gallapagos Islands, Falkland Islands. Its estimated area is about 5,500,000 square miles. Its avifauna is estimated at not less than 2250 species, or one species per 2400 miles. The characteristic forms are :—(1) Continental : *Sarcoramphus, Ibycter, Milvago, Thrasaëtus, Cymindis, Herpetotheres, Steatornis, Nyctibius, Hydropsalis, Eleothreptus, Trogon, Bucco, Monasa, Galbula, Furniarius, Synallaxis, Anabates, Oxyrhamphus, Dendrocolaptes, Pteroptochos, Rhamphocœnus, Campylorhynchus, Hylophilus, Lessonia, Agriornis, Formicarius, Formicivora, Grallaria, Tænioptera, Tityra, Conopophaga, Pipra, Rupicola, Phœnicercus, Cotinga, Gymnoderus, Cephalopterus, Vireolanius, Cyclorhis, Thamnophilus, Tanagra, Calliste, Saltator, Euphonia, Catamblyrhynchus, Phytotoma, Opisthocomus, Ramphastos, Picumnus, Celeus, Crotophaga, Cultrides, Penelope, Oreophasis, Crax, Thinocorus, Tinamus, Psophia, Cariama, Eurypyga, Parra, Palamedea, Chauna, Aramus, Merganetta, Heliornis.* (2) Antilles : *Todus, Priotelus, Cinclocerthia, Dulus, Loxigilla, Phænicophilus, Spiridalis, Glossiptila, Teretristis, Saurothera.* (3) Gallapagos : *Certhidea, Cactornis, Camarhynchus, Geospiza.* A summary of the species by Dr. Sclater is given below, with an additional column for China, founded upon Swinhoe's researches :—

	Europe.	West Africa.	N. E. Africa.	Australia.	China.	South America.
Accipitres . .	57	56	95	36	30	95
Passeres . .	238	450	372	311	171	1360
Scansores . .	12	69	38	36	30	230
Columbæ . .	7	17	14	23	4	25
Gallinæ . . .	22	19	24	16	18	80
Struthiones .	0	1	1	1	0	2
Grallæ . . .	101	99	130	78	95	128
Anseres . .	144	42	80	99	102	80
	581	753	754	600	450	2000

All the figures mentioned above, with the exception of those relating to China, accord with the state of knowledge in 1858. Although not to be relied on as applicable to the present time, they serve to give a general idea of the distribution of species. (P. L. Sclater, 'Journal of Linnean Society,' vol. ii.)

It is generally believed that the remains of extinct birds are exceedingly rare. They are certainly less abundant than those of other vertebrate animals; but their rarity is not so great as seems to be generally supposed. In a few localities they are plentiful, as, for instance, in some of the lacustrine limestones of France. As regards the present state of our knowledge respecting the ornithic forms of the past as compared with what it was fifteen or twenty years ago, there is not so much apparent advance as in other groups of the animal kingdom. We have a relic of what once existed. The imperfection of the geological record is greater in birds than in mammals, or reptiles, or fishes ; there is great difficulty in recognising the true classificatory value of the extinct forms from the osseous fragments they have left. Palæontologists have a far better grasp of the analogies, homologies, and salient features of the principal types of mammals than those of birds. They generally agree in distinguishing between certain specific specimens belonging to a mammal of predatory carnivorous habits, and others which appertain to a mammal which ate grain or vegetables ; but they are frequently unable to decide whether a well characterised specimen should be assigned to one or other of two types of birds of equally divergent nature. The *Æpyornis maximus* is an example. According to one eminent authority, it is decidedly a bird allied to the *Struthionidæ;* like the members of that group it had great powers of running, but weak powers of flight. Another observer of large experience is convinced that it had great powers of swimming, and more or less resembled a penguin or auk. And yet a third authority expresses himself with confidence that it was a near ally of that aquiline-like vulture, *Gypaetus barbatus.* The difference of opinion could scarcely be wider, since the vultures and eagles stand at the head of most classifications, and the *Struthionidæ* at the opposite extreme. This want of uniformity of opinion arises, we believe, not so much from the specimen belonging to what has been termed a comprehensive type, as from an inability to interpret correctly the facts which it reveals to us. There is an opinion that the segments of a bird's skeleton do not afford characters whereby we can confidently determine their family, generic or specific distinctness ; but Professor Blanchard has adduced good reasons for concluding that they do present such characters. If this point is gained, it will be a great boon to the investigators of the bird groups of past and present times. The number and relative position of the toes have been used as important characters in classifications ; but of late years such characters have not been estimated at so high a classificatory value as formerly; but on this point fuller details have already been given, while others will be referred to in connection with the fossil footsteps of mesozoic date. In the E. C. [Birds, vol. i. col. 437, and Grallatores, E. C. vol. ii. col. 1083] the footmarks on the sandstones in the valley of the Connecticut are regarded as of triassic age ; and such appears to be the opinion of Professor Owen, Sir C. Lyell, and many others, as expressed in their latest works ; but Professor Hitchcock, and some other American authors, who have worked most at the sandstones themselves, incline to the belief that they are newer than the trias, and that they probably belong to the upper part of the liassic or lower part of the oolitic series. The reader will find the facts adduced in support of this new position in Professor Hitchcock's 'Ichnology of New England,' 1858 ; but none of these appear to us to be decisive either way: and therefore we shall continue to call the footmark-bearing sandstones of Connecticut triassic. But whatever may be the final decision as to the triassic or oolitic age of these strata, it still remains true that the bird-tracks on them are the oldest evidence yet found respecting this class. At present no bird-bones have been obtained from these sandstones, although such are said to have been found under Aves, Fossil, E. C. vol. i. col. 351. In Professor Hitchcock's classification (1858) of the 119 species which he believes he can recognise from their tracks, thirty-one species belonging to seven genera are said to be birds. Since 1858 many other species have been described. There are ten other species which he concludes presented a combination of the lizard and the bird in their structure, and these he calls *ornithoid lizards.* And amongst the marks which he groups as lizards and batrachians, there are not a few which were at one time assigned to birds, and which have considerable resemblance to some of the tracks which are still maintained by the Professor to be those of birds. These footprints on the sands of time have been collected by thousands, and have been studied more perseveringly and successfully by Professor Hitchcock than by any one else ; but he was not the first discoverer, as stated under Ornithichnites, E. C. vol. iv. col. 122, for Deane was before him, and Moody was before Deane, since he dug up a fossil foot-track in 1802, and spoke of it as "Noah's raven." A large hall, forming the lower floor of the Appleton Cabinet, at Amherst, is filled exclusively with ichnological specimens, most of which were collected by Professor Hitchcock ; and figures of almost every kind of footstep are given in his works. Those assigned to birds present great variation of size and form. The smallest had feet not less than an inch in length, while several of the largest had a pedal length of from fourteen to eighteen inches. On the whole, they impress us with the idea that the birds of the period were remarkable for their size and stout massive feet, far exceeding anything in the living world. Assuming that there were birds at this period, the evidence does not appear to be sufficient to warrant our assigning any of them to recognised existing orders. All that can safely be said is that possibly waders tenanted North America in mesozoic days, and that we may expect to find traces of a similar group of beings in strata of the same age in favourable localities on other continental areas.

The real age of these sandstones is of some importance, since, if triassic, they contain ornithic traces of a far earlier age than anywhere else ; while if they are lower oolitic, they approximate more nearly in time to the oldest known osseous avian relics. On the former hypothesis, we should have to pass in imagination through an immense period of time, during which it may be supposed countless birds played out their allotted parts and passed out of existence without leaving any remains recognised by man. During this time were deposited the reptiliferous sandstones of Central England, the muschelkalk of Germany, the saliferous beds of Cheshire, the Penarth beds of the West of England, the whole of the liassic series, and a large proportion of the oolites. It is in the oolitic limestones of Solenhofen that have been discovered the earliest undoubted remains of a feathered biped; but although the creature has many peculiarities which are now restricted to birds, it also has a greater resemblance to reptiles than any existing bird. The old winged creature or *Archæopteryx* had a remarkable development of the caudal vertebræ which supported feathers. Further details respecting it will be found under ARCHÆOPTERYX, E. C. S.; but here we may say that its skeleton gives the general impression that the creature had the habits of a rasorial bird. According to Mr. Parker, the species of *Chauna*, a South American genus, are amongst the most lacertian of birds; and these he regards as the nearest living representatives of the *Archæopteryx*.

There are very few other ornithic remains in strata of pre-tertiary date. Most of the bones from the Wealden and cretaceous beds formerly attributed to birds, are now generally believed to belong to fishes or reptiles. The only specimens we know of are the bones from the upper greensand, near Cambridge, some of which form the *Pelagornis Barretti* of Seeley; and some remains referred to *Scolopax* from the greensand of New Jersey in North America.

When we enter upon the tertiary period, we find more abundant evidence of the existence of birds, many of which do not differ generically from living forms. By far the largest proportion of these remains have been found in Europe, so that we are scarcely able to trace in what respects the geographical distribution of the class varied from one epoch to another.

The eocene species from France comprise *Gastornis parisiensis; Circus* sp.; *Haliæetus* sp.; *Strix* sp.; *Sitta* (?) *Cuvieri*, *Centropus* (?) *antiquus*, *Coturnix*, *Perdrix*, *Scolopax*, *Tringa Hoffmannii*, *Pelidna* (?), *Ardea* (?), *Numenius gypsorum*, two species of *Pelecanus*, *Teracus littoralis*, *Camaskelus palustris*, *Elornis grandis*, *E. littoralis*, *E. antiquus*, *Dolichopterus viator*, *Mergus Ronzoni*, *Tetrao* (?), *Pessieti*, and about a dozen others whose affinities have not been determined. The English species at the same period were *Lithornis vulturinus*, *L. emuinus*, *Ptenornis* sp., *Macrornis tanaupus*, *Halcyon toliapicus*, and a few more without names. Switzerland has afforded *Protornis glariensis*.

The miocene species are mostly from France, Germany, and Greece, as indicated in the following list:—

FRANCE.

Aquila prisca.
Sp. allied to *Cathartes urubu.*
Bubo poirrieri.
B. arverniensis.
Strix antiqua.
Totanus Lartetianus.
Palælodus ambiguus.
P. crassipes.
P. gracilipes.
Anas Blanchardi.
Larus Desnoyersi.
Pelecanus gracilis.
Graculus littoralis.
Pelagornis miocænus.

GREECE.

Phasianus Archiaci.
Gallus Esculapii.
Grus Pentelici.

Besides those named there are several other French species, which have not been determined; but it is very probable that most of them will be in Milne-Edwards' 'Recherches Anatomiques et Paléontologiques pour servir à l'histoire les Oiseaux Fossiles de la France,' a magnificent work, which is now in course of publication. The German species were allied to the pheasants, sparrows, partridges, snipes, storks, and cormorants, and *Fulica*.

The pliocene species are few, and not well preserved. They comprise a falcon, a wader about the size of a heron, a swimmer nearly as large as a swan, and a species named *Gallus Bravardi* from French strata, and some fragments which have been doubtfully assigned to *Scolopax* from Œningen. A few bird bones are also recorded from the famous Siwalik beds of India.

The caverns, bone breccias, and fluviatile deposits of the post-pliocene period have yielded many remains of birds, but they are for the most part in a very fragmentary condition, which prevents their accurate determination. They appear to belong generally to species still in existence. The Brazilian caves, for instance, have afforded upwards of thirty-four species, mostly identical with those still to be found in the contiguous district. One of the most interesting species of the period is the *Gallus* from the Liege caverns.

There are also certain species which occur in strata of the recent period, and which have become extinct in many instances within the memory of man. Such are the *Dinornis*, *Palapteryx*, *Notornis*, and other brevipennate birds of New Zealand; and the Dodo, the *Æpyornis*, *Fulica*, and some psittacine birds of the Mascarene Islands. Some of these have already been noticed in E. C., while others will be mentioned elsewhere. [ARCHÆOPTERYX, E. C. S.: ÆPYORNIS, E. C. S.; DODO, E. C. S.; PSITTACIDÆ, E. C. S.; NOTORNIS, E. C. S.] We would here notice a wrong reference in E. C. vol. i. col. 473. Mention is there made of *Brachypteryx* as a New Zealand bird, and the reader is referred to BRACHYPTERYX, E. C., where, however, the only bird noticed is *Brachypteryx montana*, a native of Java. The source of the confusion is that the term *Brachypteryx* has been applied by Horsfield to a Javanese genus which has nothing to do with the New Zealand form to which Professor Owen applied the same term. The New Zealand bird is now named *Ocydromus*. The *Cimoliornis*, mentioned in the same column, is a Pterodactyle. The Pterodactyles are generally considered to be reptiles; but Mr. Seeley proposes to form them into a sub-class, distinct from reptiles; but allied to birds.

Before entering upon any remarks of our own respecting some of the statements given above, we will lay before the reader the general conclusions which M. Milne-Edwards considers may be drawn from the facts at present known. "If we rapidly glance over the facts which have resulted from the researches on fossil birds, we perceive that at one time the class was represented by forms, of which those now living afford no adequate idea. The *Archæopteryx* of Solenhofen promises to be the forerunner of a series of discoveries of the highest zoological interest, inasmuch as they will probably reveal a number of abnormal ornithic types belonging to a class which is now so homogeneous and so sharply defined. The *Gastornis parisiensis* and the gigantic footmarks of the gypseous series indicate an ornithic population as highly developed as the present. The miocene relics show that the birds of this period were very much like those of our own time; although certain families, that of *Phœnicopteridæ* for instance, abounded in representative forms, whereas now such forms are few, and rapidly falling out of the existing creation. Finally, in the post-pliocene period, the ornithological fauna was essentially the same as the present, the extinct members having probably disappeared since the invasion of man."

Few palæontologists feel more strongly than the investigators of extinct birds that the geological, or rather, we should say, the zoological record of past ages is not complete. In the case of the older ornithic faunas the known number of species is only one tithe of the number that we believe will be discovered by future research. This is partially shown by a consideration of the kinds of strata in which the remains are found, as well as of the nature of the remains themselves. We have roughly analysed the modes of occurrence, and find that the strata may be arranged in some such order as below, the most prolific being placed first. We have inserted the geological periods to which the remains found in each belong.

Limestone: oolitic, eocene, miocene.
Gypsum: eocene.
Marl: eocene, miocene, pliocene.
Sandstone: footmarks; triassic.
Caves: post-pliocene.
Loam: post-pliocene.
Sand: cretaceous, eocene, pliocene.
Clay: eocene.
Conglomerate: eocene.

In almost every case the remains are associated with evidences of terrestrial life, such as land plants, insects, mammalia, &c.; and nearly all the deposits are such as would be found either on land, in lakes, or near shores. The strata which contain the largest number of relics is mainly formed of a lime compound, while the argillaceous and sandy strata contain comparatively few. The former strata are of the kind that would be deposited rapidly from fresh waters, either in fresh waters, or in the sea. The larger proportion of the birds are waders and marsh frequenters; next in abundance are the predatory birds; and then the birds of flight frequenting the sea afford the most relics. The arboreal birds, and such as do not frequent waters, are generally rare; but they seem to be more abundant in caves, breccias, and in the surface deposits of New Zealand than in the other modes of occurrence. It is remarkable that no bones have been found corresponding with any of the species that made footsteps in the triassic and eocene beds. This appears to be inexplicable at present. One might conjecture that the tracks were made by the shore-frequenting members of the terrestrial groups; and that generally those birds were fossilized which were liable to be surprised and carried off by sudden floods, more especially the waders.

We are, however, by no means confident that the triassic footmarks were made by birds. The features generally adduced in support of this view are the three forwardly-directed toes, the progressive number of the phalanges of the toes, and the linear disposition of the tracks. The tridactyle foot is not unknown amongst reptiles. The progressive number of the phalanges is also a character met with amongst reptiles, since the monitor has toes with two, three, four, five phalanges respectively. The linear arrangement of the steps indicates a bipedal mode of progression, but it is an open question whether there may not have been bipedal reptiles. Indeed, there are a few facts which directly support this idea. The *Iguanodon* of the Wealden had tridactyle fore feet, supported by small fore limbs. The hind limbs were far larger than the fore. The footsteps left by this animal indicate that it walked permanently or temporarily on its hind legs. The same inequality in the size of the fore and hind limbs is observable in the remarkable reptilian, *Compsognathus longipes*, from the Solenhofen slates, of which Professor Huxley says ('Geological Magazine,' vol. v. p. 364):—"It is impossible to look at the conformation of this strange reptile and to doubt that it hopped or walked, in an erect or semi-erect position, after the manner of a bird, to which its long neck, slight head, and small anterior limbs, must have given it an extraordinary resemblance." We do not deny that the tracks are those of birds, but that such is the case has certainly not been proven. The fact adduced by Dana of the large proportion of uric acid found in the coprolites associated with these tracks is by no means conclusive, since it is a character which birds share with reptiles. But there appears to be further difficulties in the way of accepting the ornithic nature of these marks. The impressions are the moulds of the external portions of the foot, and, therefore, would probably indicate the position of the foot pads, or enlargements of the muscle and integuments, which should not be assumed to have coincided in number and arrangement with the phalanges. The footmarks of recent waders rarely, if ever, indicate the anatomical structure of the foot so minutely as to enable us to say how many bones each toe had. The thick, massive toes appear, at first sight, to be more in harmony with the heavy, bulky proportion of a reptile rather than the light structure so characteristic of small birds. Associated with those tridactyle footmarks are others which also have, or are supposed to have, the progressive numerical development of the phalanges; but they have four toes directed forward, a feature unknown in walking birds.

If we examine the footmarks of living birds it is rarely that the toes present an articulated character; a character which is an exceedingly prominent feature in the triassic footprints. In those cases which present traces of this feature it appears to be the exception, rather than the rule, that an idea of the osseous structure of the toes can be inferred from the impression of the foot. In some instances we find a pad corresponding to each phalange; in others the pads correspond to the articulations; while in others there is no correspondence between the number of pads and the number either of phalanges or articulations. In making these observations we do not wish to underestimate the value of ichnological testimony; since we feel sure that it will teach us much when we can correctly interpret what we see. In looking through Professor Hitchcock's 'Ichnology of New England,' we notice that in several instances the presumed possession of a tail is considered to be at once conclusive against the ornithic nature of the species, although the feet marks may be as bird-like as those which are admitted by him to be those of birds; but this argument is not so decisive now that we know of the long-tailed *Archæopteryx;* and Professor Hitchcock has recognized this, as will be seen in the quotation made below. One of the groups of footsteps was assigned by Professor Hitchcock to marsupial-like beings. In one genus the footprint had a close outward resemblance to the foot of a kangaroo; but more recently the Professor has argued in favour of this genus having been a bird, and as the views are peculiar we prefer to give them in his own words:—"The recent discovery of a remarkable animal, called by some *Griphosaurus*, and by others *Archæopteryx*, in the famous lithographic quarries of Solenhofen in Bavaria, throws some light, I think, upon the thick-toed *Lithichnozoa* [his term for the animals who made tracks on stone], while these reflect some light upon the feathered fossil. For it had feathers, yet some of the ablest zoologists pronounced it a reptile. Others, however, as Professor Owen of London, and Professor Dana of New Haven, believe it to have a predominance of ornithic characters so as to make it a bird. Some important parts of the skeleton are wanting, as the head, neck, dorsal vertebræ, and sacrum, and the ribs are detached and scattered about. The forearm consists of radius and ulna, a metacarpal bone, and a few detached small fingers; also two small slender bones with sharp claws, like those on the hind foot, which may have been used for clinging, or as weapons of offence. The lower right limb consists of a femur, tibia, and tarso-metatarsus, to which one hind toe and three fore toes are articulated, the phalanges being one, two, three, and four, though the last number is a little doubtful, on account of the position of the outer toe. The toes are all armed with sharp claws. The tail is six inches in length, and consists of twenty vertebræ, of narrow elongated form, diminishing in size to the last. The feathers of the tail are attached in pairs to each vertebra throughout its entire length.

"Now between these characters and those of some of our *Lithichnozoa*, there are some remarkable analogies or resemblances, so far as I can judge, and which I would now indicate —at least such as have arrested my attention—with some of the inferences that follow. It is perhaps unexpected that they ally the *Archæopteryx* rather to the quadrupedal *Anomæpus* than the biped tridactyles in my 'Ichnology.' (1). In both we have on the hind foot three front toes articulated to a stout tarso-metatarsal, and not as in all animals, except birds, to a tarsus of several bones. This resemblance applies also to the biped, thick-toed, tridactyle *Lithichnozoa* as well as to the *Anomæpus*, for they must all have had tarso-metatarsals below the tibia and fibula, though no impression among the tracks indicate any such bone. But we have the most decisive evidence that these animals had only three toes, and where in existing nature do we find that number articulated with anything but a tarso-metatarsal, except a few cases in the *Ruminantia* and *Solipedia.* (2). They both had the same number of phalanges in the three front toes, though a little doubt remains as to the outer toe of the latter. The same number of phalanges existed in biped *Lithichnozoa*, so far as we can judge by their tracks. (3). The posterior extremities of both, as far as the tarsal joint, correspond exactly with those of living birds; hence the tracks of the hind feet of the *Anomæpus*, as well as those of the trifid *Lithichnozoa* under consideration, are pronounced at once, on first seeing them, to have been made by birds; and it is only when we occasionally see where the *Anomæpus* brought its fore feet to the ground that we suspect it could have been four-footed. (4). Precisely how much correspondence there may be in the anterior extremities of the two animals we cannot decide. The *Archæopteryx* is thought to have had but one metacarpal bone, and the fingers are so scattered that their number is not given, but two are described as slender with long claws. The most perfect track of the fore foot of the *Anomæpus* has five toes, the two hindmost showing two phalanges; the third, four; the fourth, three; and the farthest two. The four last toes at least show small claws. The fingers are arranged so as to be fan-shaped, all pointing more or less outward, resembling an expanded wing. But they seem to be genuine fingers, and there is no appearance of feathers on any of the tracks, on the hind or fore feet. This certainly looks more like the fore foot of a lizard, and still more like that of some mammals, than the forearm of a bird, and it is difficult to conceive how it could have been used as an organ of flight; though possibly it might have been employed for prehension. But, on the other hand, we have conclusive evidence that it was not used for walking, except perhaps occasionally and imperfectly. The right and left anterior feet that made the tracks were placed almost invariably nearly abreast of each other, as if the animal were resting, and not in alternation as in walking. But of more than forty steps of *Anomæpus intermedius*, shown on the remarkable slab described in this paper, the fore feet show themselves only twice, and that when the animal rested. Indeed, we may safely assume that the principal object of the fore feet was not locomotion, and the same remark is applicable to other species, even the gigantic *Otozoum.* What other purpose in the economy of these animals could have been subserved by such a structure, except perhaps prehension, I will not attempt to describe. Yet the fact has awakened an inquiry whether such a structure may not have existed in an animal whose predominant characteristics were those of a bird. (5). But there was a tail, and how shall we reconcile that fact with an ornithic character? It might have been impossible before the discovery of the fossil at Solenhofen. But that animal had a tail six inches long with twenty vertebræ, and yet the most eminent zoologists regard it as a bird. The characters of the tail of the *Anomœpus* are very peculiar, yet there are some curious resemblances between its markings on stone and the tail of the *Archæopteryx*. The traces of the tail of the *Anomœpus* have three distinct phases. The largest species left a heart-shaped indentation, which was repeated every few inches. Would not such impressions be just what we might expect if this animal had such a short blunt tail as the *Archæopteryx?* And does it not suggest one of the uses of such a tail, viz., to furnish the animal with a sort of third hind foot to help sustain it, while it might use its fore feet perhaps for seizing upon objects above and around it. The tail of the *Anomœpus intermedius*, although rarely leaving an impression, did sometimes drag along and make a narrow continuous trail. This would indicate greater length and perhaps tenuity. But how much of attenuation and elongation might be consistent with the ornithic type, we have no means of knowing. Professor Dana speaks of a posterior elongation of the body as 'connected profoundly with inferiority of grade in the different types of animal life,' and says, that 'it is the very one of all abnormal features to be looked for in the early birds.' Upon the whole the singular markings of the tail upon stone, with the exception perhaps of *A. intermedius*, do really suggest a curious coincidence between the caudal extremity of this genus and that of the *Archæopteryx*. . . . . (6). But to return to the *Anomœpus:* which characters shall we now regard as predominating in its structure and movements, those of the bird, or those of the lizard, or of the mammal? It is difficult to avoid the conclusion that the ornithic characters are the most numerous and striking. It may, after all, have been a bird, of so low a grade, however, that, even with its skeleton before him, the anatomist would hesitate where to place it, as in the case of the *Archæopteryx*. (7). This conclusion, to which the facts and reasoning have conducted me, not without remaining doubts, would, not long since, have appeared very absurd. But if it could be admitted see what a relief it would give to difficulties. If the *Anomœpus* were a lizard or marsupial, we must give up that firmly established law of correlation which enables us to distinguish different classes of animals by the number and order of phalanges; but if it were a bird that law can still be reckoned upon among the fossil as well as the living animals. If a bird, we can see also how it was that it generally walked upon two feet, although it had another pair, to be used perhaps for several purposes, but rarely for locomotion. (8). If we can presume that the *Anomœpus* was a bird it lends strong confirmation to another still more important conclusion, which is that all the fourteen thick-toed bipeds, which I have described in the 'Ichnology,' and in this paper, were birds. In this case, if we can retain the law as to the phalanges, all the characters of the animals, as made known by their tracks, belong to birds, with little variation from the existing bird type. They were bipeds unquestionably. Since they are the most abundant of the tracks, I have now seen thousands of them, and had fore feet existed I am sure they would occasionally have left some trace of them, as in the case of every other species of *Lithichnozoa*. They had but three toes; at least if a fourth existed it must have been articulated so high as not to reach the ground. These three toes are articulated to a tarso-metatarsal, as is the case with nearly all tridactyle animals. They had the same number of phalanges as the birds. The impressions left by the cushion beneath those processes of the tarso-metatarsus which form the heel correspond to those which living birds would make, and, so far as I have examined, not to those of any other class of beings, though my examinations on this point have been few. The claws and papillæ agree essentially with those of birds. Finally the great length of stride in some cases, and the position of the tracks nearly on a right line, indicate long legs of wading birds, and not any other kind of animal. Most of these arguments are good for the ornithic origin of these tracks, whatever opinion we may entertain as to the *Anomœpus*. The only difference is, that if we regard it as a reptile, the argument from the number of phalanges must be given up; if as a bird, that strong evidence is retained. But even without this I cannot hesitate to reckon the biped thick-toed *Lithichnozoa* as birds; for I see no characters in their tracks that ally them to any other animals. I must consider them not only as birds, but as forming a quite perfect type of birds for sandstone days. The analogies taught us by palæontology would lead us to expect also in the same period a lower group of birds, and these may have been the *Archæopteryx* and perhaps the *Anomœpus* with some other genera of *Lithichnozoa* that I might name." ('American Journal of Science.' Second Series. vol. xxxvi. p. 50, *et seq.* 1863.)

The presence of the genus *Gallus* in the strata of France and Greece is interesting as showing that its range formerly extended into Western Europe, whereas it is at present not known in the native state out of Asia. It is generally believed that our poultry were originally derived from India; but as the genus existed in Greece in miocene times, and in France during the period of the cave-men, it is possible some of the breeds are domesticated European species.

BIRDS OF PARADISE [E. C. vol. i. cols. 474—480]. These gorgeous creations, the near allies of the sombre hued crows, are only to be found in New Guinea and the neighbouring islands. Many years ago Lesson voyaged through this district, and in the course of a few weeks succeeded in obtaining individuals belonging to ten or eleven different species. A few years ago the celebrated travelling naturalist, Mr. A. R. Wallace, made voyage after voyage during five successive years for the special purpose of searching for these lovely creatures; but he could only obtain by purchase or otherwise five of the thirteen species known to inhabit New Guinea. This poverty of result was owing to the far greater scarcity of the birds now than in Lesson's time. Although Mr. Wallace failed in obtaining many species he has added much to our knowledge of their distribution. On visiting the localities where Lesson obtained the majority of his specimens, Mr. Wallace soon discovered that these localities were not the places where the birds actually existed. The specimens were obtained by natives living in the interior of Borneo, and were transferred by them in the ordinary course of barter to the inhabitants of the villages on the sea coast. Owing to the extensive trading operations of the natives it is hazardous to suppose that the habitats of the birds obtained by Lesson are at the places where he bought them. The general results of Mr. Wallace's researches may be given in his own words. "Nature," he says, "seems to have taken every precaution that these, her choicest treasures, may not lose value by being too easily obtained. First we find an open, harbourless, inhospitable coast [the north shore of New Guinea], exposed to the full swell of the Pacific Ocean; next, a rugged and mountainous country covered with dense forests, offering in its swamps and precipices and serrated ridges an almost impassable barrier to the central regions; and lastly, a race of the most savage and ruthless character, in the very lowest stage of civilization. In such a country and among such a people are found these wonderful productions of nature. In those trackless wilds do they display that exquisite beauty and that marvellous development of plumage, calculated to excite admiration and astonishment amongst the most civilized and intellectual races of man. A feather is itself a wonderful and a beautiful thing. A bird clothed with feathers is almost necessarily a beautiful creature. How much then must we wonder at and admire the modification of simple feathers into the rigid, polished, wavy ribbons, which adorn *Paradisea rubra*, the mass of airy plumes on *P. apoda*, the tufts and wires of *Seleucides alba*, or the golden buds borne upon airy stems that spring from the tail of *Cincinnurus regius;* while gems and polished metals can alone compare with the tints that adorn the breast of *Parotia sexsetacea* and *Astrapia nigra*, and the immensely developed shoulder plumes of *Epimachus magnus*. I will now point out the distribution of the species of Birds of Paradise as far as I have been able to ascertain it. The Aru islands contain *Paradisea apoda* and *P. regia;* and we have no positive knowledge of *P. apoda* being found anywhere else. Mysol has *P. papuana*, *P. regia*, and *P. magnifica;* Waigiou, *P. rubra* only. Salwatty, though so close to New Guinea, has no restricted *Paradiseæ*, but possesses *P. regia*, *P. magnifica*, *Epimachus albus*, and *Sericulus aureus*. The island of Jobie and the Mysory islands beyond it certainly contain true *Paradiseæ*, but what species beyond *P. papuana* is unknown. The coast districts of the northern part of New Guinea contain *P. papuana* and *P. regia* pretty generally distributed, while *P. magnifica*, *P. alba* and *Sericulus aureus* are scarce and local. Lastly, the central mountains of the northern peninsula are alone inhabited by *Lophorina superba*, *Parotia sexsetacea*, *Astrapia nigra*, *Epimachus magnus*, and *Craspedophora magnifica;* and here also probably exist the unique *Diphyllodes Wilsoni* and *Paradigalla carunculata*. The most widely distributed of the *Paradiseæ* is, therefore, the little *P. regia*, which is found in every island except Waigiou.

Next, and probably most abundant in individuals comes the *P. papuana*, wanting only in Aru, Salwatty, and Waigiou. The next most widely spread species is *P. magnifica*, occurring in two islands (Salwatty and Mysol) as well as on the mainland. The other species are all found on the mainland only, with the exception of *P. apoda* (probably restricted to Aru), and *P. rubra*, which being certainly confined to the small island of Waigiou offers the most restricted range of the whole family. It is interesting to remark that all the islands on which true *Paradiseæ* are found are connected by banks of soundings to the mainland of New Guinea. The *hundred fathom line* includes the islands of Aru, Mysol, Waigiou, and Jobie, which have probably been at no distant geological period, connected with New Guinea; while Ké, Ceram, &c., are separated from it by deep sea, and on them no *Paradiseæ* exist. The island of Gilolo, on which the genus *Semicoptera* occurs, extends towards Waigiou, and has the island of Guebe exactly between the two, suggesting the probability of a connection between them; but the depth of the intervening sea is unknown. It may be considered as certain that every species of Paradise Bird yet obtained from the natives has come from the north peninsula of New Guinea, that being the part most frequented by the Malay traders. The vast extent of country east of 136° E. long. is quite unknown; but there can be little doubt that it contains others, and perhaps yet more wonderful forms of this beautiful group of birds. If we look round the whole circumference of the globe we shall be unable to find a region at once so promising to the naturalist, and so absolutely a *terra incognita* as this great tropical land; and it is to be hoped that our explorers and naturalists may soon be induced to direct their attention to this hitherto neglected country." ('Proc. Zool. Soc.' p. 166. 1863).

Some of the genera mentioned, viz., *Astrapia* and *Epimachus*, are not usually placed in the family *Paradiseidæ*, but to families placed next to it. The *Diphyllodes Wilsoni* mentioned in the quotation is no longer unique. A bird was obtained from Waigiou and was described in 1864 as the type of a new genus under the name of *Schlegelia calva*, but it has since turned out to be identical with *Diphyllodes Wilsoni*.

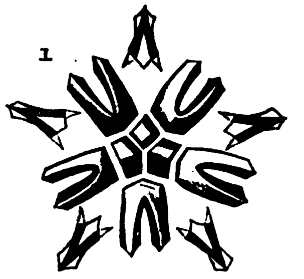
BISMUTH. Amongst the new localities for this metal may be mentioned (1) the Atlas mines of Devonshire, where it occurs in a vein containing $\frac{1}{16}$th part by weight of bismuth; having a width of three feet, and yielding 300*l.* worth of the metal per fathom; (2) the flanks of Mount Illampu in Bolivia, where it occurs in large blocks on which a few crystals of gold are occasionally found; and (3) New Zealand.

Bismuth is remarkable for expanding when it passes from the liquid to the solid form, resembling in this respect water. It is also remarkable for having its density lessened when subjected to pressure. For example, a specimen whose sp. gr. was 9·8 had its density reduced to 9·55 by a pressure of 200,000 lbs.

In the Cyclopædia article a mistake is made with reference to *Bismuth-Glance*. The 33rd line from the top of col. 482, should read thus: *Bismuth-Glance*, *Bismuthine*, a trisulphide of bismuth, &c.

BISON [E. C. vol. i. cols. 482—491]. The European bison, which appeared on English soil long before the mammoth and tichorine rhinoceros; which left its remains in the Norwich crag; which thrived during the successive periods when the land was enveloped in snow and ice, the valleys were scooped out, the gravel laid down on the valley flanks, and the caves filled with the relics of the post-pliocene fauna; which lingered on to the time of the lake-dwellers of Switzerland; of the formation of many peat bogs, and even to the 10th century, when it was used as food by the Swiss; the animal which has lived through all these changes has long ceased to be a denizen of Western Europe, and is probably only saved from extinction through the protective hand of man. Formerly it roamed over the greater part of Europe and Asia, whereas now it is only to be seen on a few isolated spots in Lithuania and Western Asia. During the period of its long existence in Western Europe it saw its original associates die off or retreat to other lands. The cave bear, the cave hyæna, the cave tiger, the mammoth, the tichorine rhinoceros, the hippopotamus, the musk ox, and the rein-deer, all gave way to the altered condition of things, and left the bison as one of the few representatives of the post-pliocene fauna. Hence the latest portion of the post-pliocene period is designated by Lartêt as the epoch of the aurochs. [POST-PLIOCENE, E. C. S.]

BLASTOIDEA, an order of Echinoderms, which has already been partially noticed under ENCRINITES, E. C. The species have somewhat the form of flower buds just about to expand into blossoms, and are supported on a long stem by which they were probably attached to the rocks. All the genera are extinct, and consequently our knowledge is entirely confined to the hard parts.



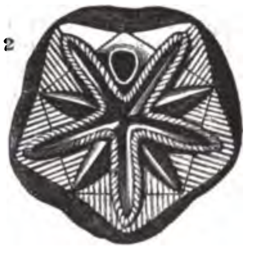


Fig. 1. Details of the calyx of *Pentremites Godonii.* Fig. 2. Summit of *Elæacrinus Verneuili.*

The calyx presents various forms, such as that of an egg, a top, an olive, and a cylinder, and is composed of a certain number of calcareous, or occasionally siliceous, plates which constitute a firm scaffold enveloping the digestive cavity. The thick outer wall of the calyx is built up of thirteen angular plates arranged in three rows. In perfect *Pentremites* there are sixteen plates in four rows; and probably the same number will be found in the other genera. Immediately above the stem are three basal pieces (*fig.* 1), two of which are pentagonal and equal, while the third is smaller and quadrangular. Upon these rest five radial pieces equal among themselves, and in most cases having on their upper side a broad deep groove. Two of the radial pieces are supported by one side only of a basal piece, while the other three are each in contact with two adjoining basal pieces. The branches of the radial pieces alternate with five inter-radial pieces, of a lanceolate subrectangular form. The five inter-radial pieces do not quite meet at the upper pole, but leave there a five-cornered aperture which is generally regarded as the mouth, although in some species of *Pentremites* and *Elæacrinus* this opening is covered by a number of calcareous plates (*fig.* 2). The grooves in the radial pieces receive the pseudo-ambulacral areas, which, according to Rœmer, are composed of three series of pieces superposed on one another. The base of each groove is occupied throughout its length by a series of compressed tubes, arranged parallel to the edges of the branches of the radial pieces; upon them is a single median lanceolate piece, which is furnished on each side with a number of small poral pieces, alternating with groups, also transverse, of still smaller pieces, known as the supplementary poral pieces. There are from ten to fifty or more of these in a row, and their total number in each individual ranges from 200 to 1000. The supplementary poral pieces are almost countless. In some species the small lanceolate piece underlies the poral pieces; and in others the supplementary poral pieces are wanting. The outermost layer of the ambulacral area is made up of a number of filiform articulated appendages, which resemble the pinnules in the arms of crinoids, while their number and bilateral arrangement correspond with those of the lateral pores, entirely covering the series of poral pieces.

The definition of the genus *Pentremites* given by Say and Rœmer has been corrected since their time by means of perfect specimens. De Koninck and Le Hon give the following description: basal pieces 3; of which one is smaller than the others; radial pieces, 1 × 5, forked and large; inter-radial pieces, 1 × 5, inter-radial, lanceolated, small; pseudambulacra, 1 × 5, covered with pinnules; buccal aperture single and central; anal aperture single and lateral; ovarian apertures, 2 × 5, situated round the mouth. The principal difference is in the number of apertures, which, according to Say, were five in number. These five apertures are in reality compound, and are situated on the summits of the inter-radial pieces. In four of these pieces the channels are divided by a central longitudinal plate, and are similar in size. The channel in the fifth piece is larger, and contains two lamellæ, which thus form three canals, the central one of which corresponds to the anus, and the two lateral ones to the oviducts. In the genus *Elæacrinus*, the buccal and anal apertures are not separated, but form a single elongated opening. More recently Mr. S. S. Lyon has disovered specimens which require a slight modification of the above definition. It should commence thus:—Basal pieces, 1 × 3, short, broad, nearly equal in size: first radial pieces [= basal pieces in the definition], 1 × 3; second radial pieces, 1 × 5, &c.

In the above description certain functions are assigned to the various apertures; but it is doubtful if any of them have been correctly named. Thus we have already noticed that the central aperture is covered in several species. In *Pentremites Norwoodi* the whole central space between the tubes at the summit of the inter-radial pieces and the anal aperture is overlaid with an integument of microscopic plates which entirely covers the central aperture, passes between the bases of the tubes in a double series of plates, and probably continues far down the central grooves of the pseudambulacral areas. In the perfect state this integument was of a sharply stellate form, the component plates being so small that a space half a line square would contain 30 of them. Mr. White has pointed out that this structure does not support the assumption that this aperture is a mouth; he also doubts whether the ovarian apertures had anything to do with the ovaries. He thinks it probable that the eggs were germinated within the body, found their way out through the central summit aperture, and were conveyed along the small central grooves of the pseudambulacral areas, beneath the plated integument, to the base of the tentacula, where they were developed and discharged.

Bronn states the number of species of *Blastoidea* at 51, all of which have been obtained either from Western Europe or the United States of America. The *Blastoidea* are represented in the Upper Silurian by three species of *Pentremites;* in the Devonian by six *Pentremites,* two *Codonaster*, one *Elæacrinus*, and one *Eleutherocrinus;* in the Carboniferous formation by 35 *Pentremites*, and three *Codonaster;* and in the Lower Chalk by two species of the doubtful genus *Phyllocrinus.* Since Bronn's work was published one species of *Codaster* (*? Codonaster*) has been found in the Carboniferous Limestone of Iowa.

(Bronn, *Die Klassen und Ordnungen der Thier-reichs*, Band. 2, 1860; White, *Boston Journal of Natural History*, vii. p. 481; Koninck and Le Hon, *Recherches sur les Crinoides des Terrains Carboniféres de la Belgique*, 1854: Lyon, S. S., *Transactions of the Academy of Science at St. Louis*, i. pp. 628—634; Shumard, in the volume last quoted, pp. 238—248; Hall and Whitney, *Report of the Geological Survey of the State of Iowa*, vol. i. pt. 2, 1858).

BLOOD [E. C. vol. i. cols. 509—517], a fluid, through whose agency nearly all the functions of organic life are performed. On this account it is of the highest interest, not only to the pathologist and physiologist, but also to the chemist and the zoologist. Its remarkable properties must also give it a high interest in the mind of the ordinary reader. It courses through the blood-vessels at rates varying from one to several inches per second, and undergoes changes in its passage through every part of the body. These changes are so numerous and so complicated that as yet we have failed to trace them in their consecutive order; but enough is known to convince the observer that they are intimately connected with the functions of the various organs, and that if rightly interpreted they afford a clear insight as to the nature of the processes which are in operation, and whether such processes are due to a healthy or morbid condition of the body. The various diseases, the different temperaments, and even the alternating feelings of the individual, such as high elation at one time, and depression at another, are more or less associated with, and in part dependent on, certain conditions of the blood. We believe the different races of men could be characterised by differences in their blood, and certainly differences are known to prevail amongst different species of animals. In the same individual the blood is constantly undergoing changes, not only from minute to minute, but during all the great ages of life, from the earliest embryonic stage through that during which the infant is mewling and puking in the nurse's arms, and on to that of second childhood, when ends the strange eventful history of our life. It is very probable that the order of the evolution of the various organs is determined by the condition of the blood; as also the remarkable correlation between all parts of a structure; and many of the facts connected with the variation of species. The morphologist knows that hair is always associated with creatures who suckle their young, but he can give no reason why it is so. The zoologist knows that under certain conditions the female bird will assume the plumage of its mate, and that the castrated stag will not develop its lordly antlers, so distinctive of its sex, and that eunuchs do not possess beards. Facts of a similar kind might be cited by hundreds. They all illustrate the principle that, when the composition of the blood is altered, either by the withdrawal from it of something which supplies a new functional organ, or by the addition to it of something which would otherwise have supplied some organ, a change takes place in some other part of the body. The data upon which these hypothetical views are founded will be given in the sequel; our object at present being to impress upon the reader that the blood does not possess that definite unvarying character which is commonly supposed, but that it is always on the change. Notwithstanding this, however, its general character is remarkably uniform and constant. It is owing to this that the analyses given in books have lost so much of their value, since they seldom tell us from what part of the body, and under what conditions, the specimens were obtained. Illustrations of this point will be referred to in the course of this article.

The quantity of blood in the human body is generally estimated at about one-twelfth of the weight of the individual; so that there would be from 12 to 15 lbs. in a man of average height. In some instances it may be even more than this; for cases are on record in which 24 lbs. were collected from the body of a decapitated female; and Bernard has made the important observation that a fasting animal will yield only half the quantity that may be obtained from it after a full meal. Judging from the rough imperfect measurements which have been made, it would seem that animals generally have a smaller quantity of blood relatively to their bulk than men. Thus Herbert estimated the proportion between the weights of the blood and the whole body to be as 1 to 12 in the ox; 1 to 16 in the dog; 1 to 18 in the horse; 1 to 20 in the goat, calf, lamb, and hare; 1 to 22 in the sheep and cat; and 1 to 24 in the rabbit. These figures are not to be relied on too fully, since it is an extremely difficult thing to ascertain correctly the quantity of blood, and since it is essential that the individuals should be under corresponding conditions as regards their state of health, their temperament, the quantity of food within them, and the time when they took it, their age, their size, whether above or below that of the average of the species, and other points, which are seldom attended to by experimenters, and still seldomer mentioned in the published descriptions of experiments.

When circulating in the body, the blood consists of two parts, or corpuscles, floating in a fluid called the "liquor sanguinis." The liquor sanguinis itself consists of various ingredients, being an aqueous solution of fibrin, albumen, several salts, and a few gases. As it is convenient to be able to compare the relative compositions of the corpuscles and the fluid in which they are immersed, we append here Strecker's analyses of them; the numbers indicate the proportion of each ingredient in every 1000 parts:—

	Red Corpuscles.	Liquor Sanguinis.
Water	688·00	902·90
Solid residue	312·00	97·10
Hæmatin (including iron) . .	16·75	—
Globulin and cell membrane .	282·22	—
Fibrin	—	4·05
Albumen	—	78·84
Fat	2·31	1·72
Extractive matter	2·60	3·94
Mineral substances	8·12	8·55
Chlorine	1·686	3·644
Sulphuric acid	·066	·155
Phosphoric acid	1·134	·191
Potassium	3·328	·323
Sodium	1·052	3.341
Oxygen	·667	·403
Phosphate of lime	·114	·311
Phosphate of magnesia . . .	·073	·222

The corpuscles are of three kinds—viz. (1) the colourless nucleated, (2) the red nucleated, or pyrenæmatous; and (3) the red, non-nucleated, or apyrenæmatous; and perhaps there is a fourth kind. But little is known respecting the last, and all that can be said of it is that it is very small, almost transparent, and unaffected by acetic acid.

The first kind, or the colourless nucleated corpuscle, is found in all the vertebrated animals. A similar corpuscle is met with in the invertebrata, but it has not been ascertained whether it is to be identified with that in the blood of the higher animals. In the Vertebrate sub-kingdom these corpuscles are circular or slightly oval, and their size varies but little. In the higher animals their diameter is about $\frac{1}{3000}$th of an inch, while in the reptiles they are a trifle longer, or about $\frac{1}{2500}$th of an inch. They are somewhat larger than the corpuscles of lymph, from which they further differ in being nucleated, and in being energetically acted upon by acetic acid, which causes the nucleus to contract upon itself, and become more distinct. The colourless corpuscles are more firm, less elastic, and move more slowly in the blood-vessels than the red corpuscles; they do not adhere together, and they move along the outside of the current close to the sides of the blood-vessels. These facts have already been mentioned in the Cyclopædia article; but we wish to associate them with the observation of Wharton Jones that they undergo incessant modifications of form. Their circumference is bulged out from time to time in protrusions, which are retracted in one place and then pushed out in another, reminding one of the similar action of the Amœba and other rhizopods. These motions are best seen in those corpuscles which are adherent to the sides of the blood-vessels. There is a paper, by Hering, on the knowledge of the vitality of blood-cells ('Zur Lehre vom Leben der Blutzellen') in the 'Sitzungsberichte' of the Academy at Vienna (vol. 56, abtheilung ii., and vol. 57, abtheilung ii.). In it he notices the remarkable resemblance between the lymph-cells and the young colourless blood cells; the facility with which the latter change their forms; and the tendency they have to adhere to the walls of the capillary channels. Their extraordinary pliability when thus adherent is referred to. Thus he states that he has seen such globules drawn out to three or four times their ordinary diameter by the force of the blood-current. When thus fixed the contents of the globules are dialized out through the walls of the capillaries; and sometimes, as is stated, the corpuscles themselves work their way through the sides of the vessel. The latter observations have been confirmed by Cohnheim and others. The same periodical contains, in the volumes for 1867 and 1868, several important papers on this and other subjects relating to the blood, by Stricker, Brücke, Rovida, and Golubew. The corpuscles are found to vary considerably in number, being four or five times as numerous at one time as at another. Thus Dr. Hirt has found them to be in the proportion of 1 colourless to 716 coloured corpuscles before breakfast; 1 to 347 half an hour after breakfast; 1 to 429 half an hour after dinner; and 1 to 544 half an hour after supper; 1 to 1514 about three hours after breakfast; 1 to 1481 about the same lapse of time after dinner; and 1 to 1227 about a similar interval after supper. They increase after a meal, and diminish in the intervals, with the exception of that between supper and breakfast, when, if Dr. Hirt's observations are to be relied on, they increase. They abound in the blood of the splenic vein; are more numerous in youth than in mature age, and form a large proportion of the blood in reptiles and fishes, or one-sixteenth of a frog's blood in February, and one-sixth in August. In *Amphioxus*, and the invertebrata generally, they form the entire bulk of the blood. In man and the higher animals they are sometimes developed in such numbers as to form the disease termed *leucocythæmia:* it prevails in individuals suffering from affections of the spleen, liver, and lymphatic glands, and is accompanied by a marked increase in the quantity of fibrin. These corpuscles abound more in young, sickly, and ill-fed individuals, than in those who are old, or healthy, or well-fed. They seem to be developed most when the nutritive functions are in the highest state of activity, and to accumulate most in young individuals in which the nutritive functions are in partial abeyance. The association of abnormal quantities of fibrin and colourless corpuscles appears to be a coincidence rather than a relation of cause and effect. Thus Mr. Paget has observed that a blister produces a different kind of matter in a healthy than in a very unhealthy individual. In the former it consists almost entirely of firm fibrin, while in the latter the colourless corpuscles are unusually abundant.

The red corpuscles are, as we have said, of two kinds, but as the paler variety is frequently referred to in physiological books as the colourless corpuscle, it is difficult to ascertain whether the remarks refer to the colourless nucleated corpuscle already described, or the nucleated corpuscle which we are about to notice. Under these circumstances, we shall follow Mr. Gulliver as our guide. The nucleated corpuscle is a cell within a cell, of an oval shape, of a generally pale colour in the lower vertebrates, being almost colourless in fishes, and pale yellow in reptiles, while in birds they are of a brighter red even than in the mammalia. In man and the mammalia, corpuscles supposed to be identical with these are developed in the earliest embryonic stage, and have disappeared entirely long before birth, when they are replaced by the permanent set of red corpuscles, which are much smaller in size. Mr. Gulliver dwells especially upon this discovery of the presence of a nucleus in the principal blood-corpuscles of the lower vertebrates, and of its absence in those of the higher. "Thus," he remarks, "is plainly unfolded the most universal and essential difference ever before discovered between the mammalia and the oviparous vertebrates; for this one minute point is in truth so large and extensive as to clearly characterise the divisions in question in any sex, and at any age, which not one of the old diagnoses will effect;" and on this basis he proposes to classify the vertebrate sub-kingdom into the two great groups of *Pyrenæmata*, or those which have a nucleated blood-corpuscle, and the *Apyrenæmata*, in which the blood corpuscle is not nucleated. In birds, they vary from a broad to a narrow elliptical shape, but do not generally present any greater divergence in size than is to be found in a single order amongst mammalia. The blood-corpuscles of reptiles are similar to those of birds in structure and shape, but vary widely in size. They are largest in the naked amphibia, more especially in those which retain their branchiæ through life, and are smallest in the lizards, tortoises, and serpents. Those of the *Proteus* and *Lepidosiren* have long been noticed as the largest, both relatively to the size of the species, and absolutely; and of late years it has been ascertained that in the kindred species, the *Sieboldia maxima*, they are almost as large as in *Proteus*. The difference in the size of the corpuscles of *Sieboldia* and the Crocodile is remarkable, the former is an animal about 3 feet long, and its corpuscles are such, that 450 of them placed end to end would cover the space of an inch, whereas it would require 1230 of the corpuscles of the crocodile, an animal 20 feet long, to cover the same space. In fishes, the corpuscles are more tender, and less durable than those of reptiles and birds; and they present considerable variety of size and shape. They are on the average far smaller than those of reptiles; they are largest in the sharks, and perhaps smallest in the cyclostomes. They are oval in the former group, and round in the latter.

The red corpuscles, without nuclei, are biconcave bodies, with a raised circular margin. They are non-homogeneous, and consist of a colourless membranous base, with a semi-fluid or viscid matter in which the colour resides. This matter, which forms the chief bulk of the corpuscle, is very soluble in water. The corpuscles are slippery, soft, elastic, and viscid; will assume a variety of forms, generally returning to their regular shape, and stick together in piles, sideways or edgewise. If they are washed in water, the membranous base remains behind, and is the globulin of some authors. They are, in this state, quite insoluble in water, and so transparent, that it requires the action of corrosive sublimate to render them sufficiently opaque to be seen. There are, however, a few exceptions to the statement that the shape is circular and biconcave, since amongst the *Camelidæ* they are oval; but they may at once be distinguished from the similarly shaped corpuscles of other vertebrates, since they have no nucleus. The corpuscles are thin-walled, hollow bodies, whose shape is more or less influenced by the density of the fluid, without and within them. There is apparently a constant osmotic action, and any marked change in the relative densities of the liquor sanguinis and the fluid within the corpuscle will at once cause its shape to vary. It is in this way we may account for the strange shapes that are exceptionally met with. At times we find them swollen, puckered, or shrunk into a variety of figures, such as flat, band-like, or shallow circular or oval cups, stellate, notched, granulated, mulberry-shaped, crescentic, angular, lanceolate, fusiform, comma-shaped, &c. Amongst the *Cervidæ* these strange forms appear to be unusually abundant. The biconcavity of human blood-corpuscles is an indication that the fluid of the liquor sanguinis is passing into it faster than the fluid within the corpuscle can pass outwards; but they have been seen to change their shapes suddenly, and it is probable that the alteration is due to some disordered state of the system. If some of these red corpuscles be placed in a fluid of less density than 1·028, water being 1, they first lose their concavity and become flat; by a further continuance of the operation they become biconvex, and finally globular; and by regulating the density of the fluid in which they are immersed, we can produce in them any degree of concavity we desire. The size of the apyrenæmatous corpuscles appears to be dependent on several things. Generally speaking, they are largest in the largest species, and smallest in those of minute size. Exceptions are numerous, and appear to have some relation to the general vital activity, and to the complexity of the organism. Thus, of two equally sized vertebrates, that one will possess the largest corpuscles which stands lowest in the scale of organization, or which has the smaller vital activity. The size of the corpuscle will, therefore, in most cases, correspond first to the size of the individual, and next to its muscular and respiratory activity. There are also other modifying influences, which appear to prevent the rigid application of this rule. Dr. Davy states that the size

has an important relation to animal heat, which, in most cases, is greatest in the most active breathers. This relation of size is interesting, since the corpuscles are believed to be oxygen carriers, and they will be more active, weight for weight, the smaller they are, since the greater the number in a given weight the larger is the superficial area presented for chemical and physical processes. The following is an abstract of Gulliver's observations on the corpuscles of the different mammalian orders. In man they are larger than in most mammalia. Those of the *Quadrumana* differ little from those of man, but are generally somewhat smaller. Those of the *Cheiroptera* and *Insectivora* are smaller than those of monkeys. Amongst the *Feræ* they differ considerably in size, but in some of the minor groups they are remarkably uniform. If arranged according to the size of the corpuscles, the groups would stand thus, those with the largest being placed first; seals, dogs, bears, weasels, cats, viverrines. In the seals, otters, and dogs, the corpuscles are of about the same size as those of man; while those of the viverrines are as small as those of some *Ruminantia*. The genera *Bassaris* and *Cercoleptes* have been bandied about between the ursine and viverrine families by zoological classifiers; but judged by the present test, the former should be classed with the bears, and the latter with the viverrine group. Amongst the *Pachydermata*, the elephant has larger, and the rhinoceros, tapirs, pigs, and horses have smaller, corpuscles than man; while in the *Hyrax* they are remarkably large for the size of the animal, in which feature it is more like a rodent than a pachyderm. Amongst whales, the corpuscles are larger in *Balæna* than in man; of about the same size in the caa'ing-whale, and rather smaller in the porpoise. The corpuscles are characteristically small in the Ruminants. The *Moschidæ* have the smallest corpuscles known. They are somewhat larger in the brocket deer, and ibex; and increase as we pass from the common goat and sheep to the larger species in which they are larger than in most of the *Viverridæ*. The Rodents have large corpuscles, those of the little harvest-mouse rivalling those of the horse and peccary in size, while the capybara has larger corpuscles than man. The corpuscles of the Edentates are large. In the little armadillo they are somewhat smaller than in man; but those of the two-toed sloth and great ant-eater are much larger. The Marsupials resemble the Rodents in the size of the corpuscles, and the Monotremes resemble man in the same respect. In speaking of the size of the corpuscles, the average is meant; for they vary even in the same individual, some being one-third larger or smaller than others; and the proportion of these exceptionally-sized corpuscles probably varies from time to time.

In our further remarks we shall allude to both these corpuscles generally as the red corpuscles, using the terms nucleated and non-nucleated when it is desired to refer to either of them separately. There is much uncertainty as to the cause of the variation in the colour of the blood from bright scarlet to dark purple. The explanations offered in the original article are plausible, but the same results may be produced in other ways which are equally plausible, and the difficulty is to decide the actual way in which it is produced, and not how it may be done. As a general rule, arterial blood has a bright scarlet tint, while venous blood is a dark red. The difference is most marked in individuals which have a slow or weak respiration, or dwell in cold climates; and it is least marked in those which have an unusually active respiration or dwell in warm climates. The florid hue is most extensive wherever the largest amount of oxygen has been absorbed. If all the gases be withdrawn from the blood, both the arterial and venous varieties present the same dull black tint. The colour is due to the red corpuscles and the changes they undergo. Although they are so minute, their superficial area is surprising, but it is difficult to estimate it. Vierordt has calculated that a cubic centimetre of human blood contains no fewer than 5,055,000 red corpuscles, and Welcker 4,600,000. Taking the former as a basis, it would yield upwards of 83 millions in every cubic inch, and if we estimate the whole quantity of blood in the system at 15 lbs. or a gallon and a half, it would give upwards of 38,445,000,000 red corpuscles for the whole body. Their total superficial area would be between 50 and 60 square feet. It is noticeable that the corpuscles are biconcave, by which arrangement the same superficial area is obtained in a much smaller space than if they were simply globular; but what is the object of it we are unable to indicate; the effect of it is to allow of a larger proportion of liquor sanguinis for the same amount of corpuscular surface. It is supposed that the biconcavities may be an element in the alteration of colour, and there is as much evidence in favour of this view as of the one usually accepted, that the alteration of colour is due to the action of oxygen and carbonic acid on hæmatin. It is true that when withdrawn from the body arterial blood may be coloured like venous by the action of carbonic acid, and the contrary change brought about by means of oxygen; but the same changes are effected in another way. If, for instance, arterial blood be deprived of a portion of its fibrin, and be diluted with water, it acquires the aspect of venous blood; and the red colour may be restored by the action of a saturated solution of a neutral salt, while oxygen is unable to do it. Venous blood may be reddened by means of a similar saturated solution, but carbonic acid will not render it dark again. Hence it is not safe to conclude that the light or dark colour always indicates the relative abundance or scarcity of oxygen and carbonic acid gases. The changes of colour in the above illustration appear to be regulated by variations in the density of the fluid surrounding the corpuscles. When its specific gravity is lessened by the addition of water, the corpuscles are darkened, but when it is increased by the addition of a strong solution, they become lighter. That such variations do take place in the density of the liquor sanguinis is well known, but it remains to be proved whether such changes are the real agents. The following remarks by Dr. Carpenter especially apply to this point. "The blood contained in the veins of muscles is dark, and always of a deeper shade in proportion to the energy and duration of the previous muscular contraction, whilst that returning from the gland is always brighter in proportion to the activity with which secretion is being formed; and in the latter instance, with the alteration in colour, the amount of fibrin is found to be diminished, or so modified as to form a softer clot, from which a large quantity of serum separates. It is remarkable that if the dark coloured clot of ordinary venous blood be immersed in the serum of the scarlet venous blood, it rapidly assumes a brighter tint, and conversely the clot of scarlet venous blood changes to a dark colour when immersed in the serum of deep coloured venous blood; from which we may conclude that the primary changes are effected upon the liquor sanguinis, and not upon the corpuscles." Professor Stokes has examined the blood with the spectroscope, with a view to ascertaining what are the colouring matters, and in what way the transition from the purple to the scarlet hue is effected. He details a series of observations from which he infers that "the colouring matter of the blood is capable of existing in two states of oxidation, distinguishable by a difference of colour, and by a fundamental difference in the action on the spectrum. It may be made to pass from the more to the less oxidized state by the action of suitable reducing agents, and recovers its oxygen by absorption from the air." This colouring matter, in its two-fold state, he terms purple and red cruorine. This substance is exceedingly unstable in its nature, so that while it will take up oxygen greedily it parts with it again readily, and it is easily decomposed. Amongst the products of decomposition is hæmatin, which is far more stable, but otherwise it has considerable resemblance to cruorine in some of its chemical features. In order to illustrate what may be the functions of cruorine, Prof. Stokes describes an experiment, and offers comments upon it. A solution of protoxide of tin was rendered alkaline, and to it was added some tartaric acid. When some of this was added to a moderate quantity of a solution of scarlet cruorine, the latter was reduced, but was again oxidized by being shaken up with air. On standing for about two minutes it was again reduced, and could be reoxidized by further agitation with air. It thus appears "that purple cruorine absorbs *free* oxygen with much greater avidity than the tin solution, notwithstanding that the oxidized cruorine is itself reduced by the tin salt." His comments are to the following effect:—"As the purple cruorine in the solution was oxidized almost instantaneously on being presented with free oxygen by shaking with air, while the tin salt remained in an unoxidized state, so the purple cruorine of the veins is oxidized during the time, brief though it may be, during which it is exposed to the air in the lungs, while the substances derived from the food may have little disposition to combine with free oxygen. As the scarlet cruorine is gradually reduced, oxidizing thereby a portion of the tin salt, so part of the scarlet cruorine is gradually reduced in the course of the circulation, oxidizing substances derived from the food or of the tissues. The purplish colour now assumed by the solution illustrates the tinge of venous blood, and a fresh shake represents a fresh passage through the lungs." ('Proceedings of the Royal Society,' vol. xiii.) The quantity of red corpuscles may vary considerably within the limits of health, and still more widely in diseased conditions of the body. On the average it is greater in males than in females

by from 1 to 2 per cent.; in the higher vertebrates than in the lower; and in individuals of a sanguineous than in those of a lymphatic temperament. In anæmia, chlorosis, scurvy, albuminuria, and other diseases, there is a decrease of the corpuscles from the normal abundance. Considering that the blood is entirely confined within a system which has no direct communication with the open air, any information that gives the slightest clue as to the method of its formation is of importance. In this connection, then, we would mention Dr. Roberts' experiments on the corpuscles. On treating them with a solution of magenta the pale variety was more deeply tinted than the dark, and its nucleus was conspicuous on account of the bright carbuncle red which it acquired. These nuclei were observed to be in various stages of division, and were seen to liberate secondary nuclei, which passed into the blood, and by subsequent enlargement, change of form, and chemical composition, to develope into red blood-disks. By treatment with carbolic acid the corpuscles appeared as though their contents had separated themselves from the corpuscular wall, and had collected among the nuclei.

The red corpuscles consist of an albuminous base, or globulin, and of certain colouring matters. Bojanowski recognises four varieties, which he calls hæmatoglobulin, hæmatoidin, hæmatin, and hæmin; but our ideas concerning them are far from being precise, and it is probable that all the different varieties of colouring matter are variable mixtures of two definite compounds. The hæmatoglobulin may be obtained in crystals from blood which has been long exposed to cold air, but their shapes vary in different animals. They will dissolve in water, acetic acid, and ammonia, but not in alcohol. There is a marked difference in the crystalline varieties of this substance. Those of man will dissolve in 94 parts of water, while those of the guinea-pig require 600 parts for solution. The analysis of three specimens afforded Lehmann the following results:—

Carbon . . .	55·41	55·24	54·18
Hydrogen . .	7·08	7·12	7·14
Nitrogen . . .	17·27	17·31	16·40
Sulphur . .	·25	·21	·25
Oxygen . . .	19·99	25·12 (? 20·12)	20·03 (? 22·03)
	100·	100·	100·

Notices of hæmatoglobulin will be found under Hematocystallin, E. C., A. and Sci. Div.; of hæmatin, under Hematosin, in the same division; and of hæmatoidin under the same name in that division. Of hæmatoidin we will only say here, that it is probably formed from hæmatin by decomposition. Hæmin occurs in rhombic crystals, those of men being readily distinguished from the crystals yielded by the blood of domestic animals, and hence their form is frequently employed as a test of the character of blood-stains in medico-legal inquiries. They are of dark brown or black colour, but are rendered violet by oxygen, and again opaque by subsequent treatment with carbonic acid. Globulin, which forms the great bulk of the corpuscle, is a modified form of albumen, and has the same percentage composition. The analyses given by Lehmann of hæmatoglobulin are identical with the results afforded by globulin. Globulin is the albuminous constituent of the corpuscle, and represents the albumen of the liquor sanguinis.

We now pass from the corpuscles to consider the fluid in which they float. It is a solution, the constituents of which are liable to constant change within certain narrow limits. Amongst those constituents we have mentioned fibrin, but it is not certain that this substance pre-exists in a state of solution. It has been suggested that when it separates from the blood, forming the well-known phenomenon called coagulation, it is then formed for the first time from two substances already existing in the blood. In the E. C. article the fibrin is said to be mechanically suspended in the blood, but this is certainly not the case. Coagulation has been much studied, but although inquirers appear to be approaching the truth as to the causes which produce it, and its significance as throwing light upon the formation of the blood, they have yet far more to learn. Coagulation is for the most part the result of a combination of circumstances external to the body itself. When the blood is withdrawn from the system, and exposed to the air, the corpuscles begin to sink, while minute fibres form in the fluid, beginning at the sides of the vessel at the surface, and creeping towards the centre. This proceeds so rapidly in most cases that the fibrin entangles many of the corpuscles in its meshes, and so forms the clot. The coagulum is a fibrous solid, especially remarkable since it presents an arrangement analogous, or probably identical in character with that of organized structure, and the resemblance is greatest when highly vitalized fibrin coagulates very slowly on a living membrane, and produces a fibrous tissue with blood-vessels traversing it. It only differs from the tissue formed *within* the living organism in being less distinctly fibrous. With regard to the time mentioned in the E. C. article which the clot takes to form, it is true for the majority of cases, but it is by no means constant. It takes a very long time in individuals which have been killed by lightning, electric shocks, and asphyxia, and it may be retarded or accelerated in various ways. Many facts are on record which support the hypothesis that fibrin is the result of the combination of two distinct substances, and this hypothesis has received considerable support from the researches of M. Alexander Schmidt, of Dorpat, an analysis of which is given in the 'Natural History Review' for 1864. For instance, by adding the serum of blood (a fluid which presents no tendency to coagulate, and which is supposed to be perfectly free from fibrin, since that has been thrown down in the blood clot) to any other serous fluids which themselves do not possess any power of spontaneous coagulation, we obtain a clot of fibrin. The serous fluids are believed to be coagulable by themselves soon after withdrawal from the living body, but they soon lose their power. The power is at once restored to them by the addition of blood serum. From this it would seem that the two fluids possess, when combined, some condition which is wanting in their separate states. Blood serum has a very feeble coagulating power, and it has been disassociated from the fibrin and the corpuscles. The addition of fibrin to it has no effect; but if only a few corpuscles be added, its coagulation is greatly increased, and if a microscope be employed, the corpuscles will be seen to be the centres of the coagulating force. The blood crystals, termed hæmatoglobulin, have a similar coagulating power. Schmidt supposes that the blood corpuscles contain a constituent which, combining with another in the serum, forms fibrin. Accordingly he groups all substances which act like the corpuscles as *fibrinoplastic* agents, and those which behave like serum *fibrinogenous*—terms which may be used for these ideas without implying the existence of any substance known as *fibrinoplast* and *fibrinogen*, as Schmidt does. On passing carbonic acid through fibrinoplastic fluids globulin is obtained, which forms the essential part of corpuscles and blood crystals, and which is regarded by Schmidt as one of the constituents of fibrin. It is found in all the coagulative fluids, such as the aqueous humour, saliva, synovia, connective tissue, and elsewhere. Globulin loses its fibrinoplastic powers when long exposed to the air, or subjected to a temperature of 158° F.; but they are increased by an alkaline solution just sufficiently strong to dissolve it, while it is weakened or destroyed in stronger solutions. 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We now pass from the corpuscles to consider the fluid in which they float. It is a solution, the constituents of which are liable to constant change within certain narrow limits. Amongst those constituents we have mentioned fibrin, but it is not certain that this substance pre-exists in a state of solution. It has been suggested that when it separates from the blood, forming the well-known phenomenon called coagulation, it is then formed for the first time from two substances already existing in the blood. In the E. C. article the fibrin is said to be mechanically suspended in the blood, but this is certainly not the case. Coagulation has been much studied, but although inquirers appear to be approaching the truth as to the causes which produce it, and its significance as throwing light upon the formation of the blood, they have yet far more to learn. Coagulation is for the most part the result of a combination of circumstances external to the body itself. When the blood is withdrawn from the system, and exposed to the air, the corpuscles begin to sink, while minute fibres form in the fluid, beginning at the sides of the vessel at the surface, and creeping towards the centre. This proceeds so rapidly in most cases that the fibrin entangles many of the corpuscles in its meshes, and so forms the clot. The coagulum is a fibrous solid, especially remarkable since it presents an arrangement analogous, or probably identical in character with that of organized structure, and the resemblance is greatest when highly vitalized fibrin coagulates very slowly on a living membrane, and produces a fibrous tissue with blood-vessels traversing it. It only differs from the tissue formed *within* the living organism in being less distinctly fibrous. With regard to the time mentioned in the E. C. article which the clot takes to form, it is true for the majority of cases, but it is by no means constant. It takes a very long time in individuals which have been killed by lightning, electric shocks, and asphyxia, and it may be retarded or accelerated in various ways. Many facts are on record which support the hypothesis that fibrin is the result of the combination of two distinct substances, and this hypothesis has received considerable support from the researches of M. Alexander Schmidt, of Dorpat, an analysis of which is given in the 'Natural History Review' for 1864. For instance, by adding the serum of blood (a fluid which presents no tendency to coagulate, and which is supposed to be perfectly free from fibrin, since that has been thrown down in the blood clot) to any other serous fluids which themselves do not possess any power of spontaneous coagulation, we obtain a clot of fibrin. The serous fluids are believed to be coagulable by themselves soon after withdrawal from the living body, but they soon lose their power. The power is at once restored to them by the addition of blood serum. From this it would seem that the two fluids possess, when combined, some condition which is wanting in their separate states. Blood serum has a very feeble coagulating power, and it has been disassociated from the fibrin and the corpuscles. The addition of fibrin to it has no effect; but if only a few corpuscles be added, its coagulation is greatly increased, and if a microscope be employed, the corpuscles will be seen to be the centres of the coagulating force. The blood crystals, termed hæmatoglobulin, have a similar coagulating power. Schmidt supposes that the blood corpuscles contain a constituent which, combining with another in the serum, forms fibrin. 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We now pass from the corpuscles to consider the fluid in which they float. It is a solution, the constituents of which are liable to constant change within certain narrow limits. Amongst those constituents we have mentioned fibrin, but it is not certain that this substance pre-exists in a state of solution. It has been suggested that when it separates from the blood, forming the well-known phenomenon called coagulation, it is then formed for the first time from two substances already existing in the blood. In the E. C. article the fibrin is said to be mechanically suspended in the blood, but this is certainly not the case. Coagulation has been much studied, but although inquirers appear to be approaching the truth as to the causes which produce it, and its significance as throwing light upon the formation of the blood, they have yet far more to learn. Coagulation is for the most part the result of a combination of circumstances external to the body itself. When the blood is withdrawn from the system, and exposed to the air, the corpuscles begin to sink, while minute fibres form in the fluid, beginning at the sides of the vessel at the surface, and creeping towards the centre. This proceeds so rapidly in most cases that the fibrin entangles many of the corpuscles in its meshes, and so forms the clot. The coagulum is a fibrous solid, especially remarkable since it presents an arrangement analogous, or probably identical in character with that of organized structure, and the resemblance is greatest when highly vitalized fibrin coagulates very slowly on a living membrane, and produces a fibrous tissue with blood-vessels traversing it. It only differs from the tissue formed *within* the living organism in being less distinctly fibrous. With regard to the time mentioned in the E. C. article which the clot takes to form, it is true for the majority of cases, but it is by no means constant. It takes a very long time in individuals which have been killed by lightning, electric shocks, and asphyxia, and it may be retarded or accelerated in various ways. Many facts are on record which support the hypothesis that fibrin is the result of the combination of two distinct substances, and this hypothesis has received considerable support from the researches of M. Alexander Schmidt, of Dorpat, an analysis of which is given in the 'Natural History Review' for 1864. For instance, by adding the serum of blood (a fluid which presents no tendency to coagulate, and which is supposed to be perfectly free from fibrin, since that has been thrown down in the blood clot) to any other serous fluids which themselves do not possess any power of spontaneous coagulation, we obtain a clot of fibrin. The serous fluids are believed to be coagulable by themselves soon after withdrawal from the living body, but they soon lose their power. The power is at once restored to them by the addition of blood serum. From this it would seem that the two fluids possess, when combined, some condition which is wanting in their separate states. Blood serum has a very feeble coagulating power, and it has been disassociated from the fibrin and the corpuscles. The addition of fibrin to it has no effect; but if only a few corpuscles be added, its coagulation is greatly increased, and if a microscope be employed, the corpuscles will be seen to be the centres of the coagulating force. The blood crystals, termed hæmatoglobulin, have a similar coagulating power. Schmidt supposes that the blood corpuscles contain a constituent which, combining with another in the serum, forms fibrin. Accordingly he groups all substances which act like the corpuscles as *fibrinoplastic* agents, and those which behave like serum *fibrinogenous*—terms which may be used for these ideas without implying the existence of any substance known as *fibrinoplast* and *fibrinogen*, as Schmidt does. On passing carbonic acid through fibrinoplastic fluids globulin is obtained, which forms the essential part of corpuscles and blood crystals, and which is regarded by Schmidt as one of the constituents of fibrin. It is found in all the coagulative fluids, such as the aqueous humour, saliva, synovia, connective tissue, and elsewhere. Globulin loses its fibrinoplastic powers when long exposed to the air, or subjected to a temperature of 158° F.; but they are increased by an alkaline solution just sufficiently strong to dissolve it, while it is weakened or destroyed in stronger solutions. An acid solution masks its powers, so that the stronger it is the larger is the quantity of alkali required to counteract the acid, and to restore the powers. It appears, however, to be necessary that the globulin should be in some particular condition about which nothing is known. Having found, as he thought, one of the constituents of fibrin, Schmidt applied himself to the discovery of the other. He saturated a fibrinogenous liquid with carbonic acid, and obtained a substance which was found to give a clot with blood serum. It resembled globulin in its general behaviour towards reagents, but differed as regards its sensitiveness towards them, being more easily precipitated from its solutions by alcohol. There was, however, still something wanting, for when the prepared fibrinogenous and fibrinoplastic fluids were mixed, it was seldom a coagulum could be obtained, and then only an imperfect one. This last difficulty will, no doubt, be removed when some one undertakes a complete examination of the causes which induce the formation of the numerous albumen and albumen-like compounds. The result of this part of the inquiry is summed up by the writer of the article in the 'Natural History Review' in the following terms :—"All fibrinoplastic substances are found to contain globulin. Deprived of their globulin, they lose their coagulating virtues. Globulin itself is highly fibrinoplastic; added to a fibrinogenous liquid it disappears, giving rise to fibrin. By no other means than by the action of a fibrinogenous liquid can globulin, so far as is yet known, be converted into fibrin. All fibrinoplastic liquids are found to contain a substance called fibrinogen. Deprived of their fibrinogen, these liquids will no longer coagulate on the addition of globulin. Fibrinogen added to a fibrinoplastic fluid disappears, giving rise to fibrin. 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In our further remarks we shall allude to both these corpuscles generally as the red corpuscles, using the terms nucleated and non-nucleated when it is desired to refer to either of them separately. There is much uncertainty as to the cause of the variation in the colour of the blood from bright scarlet to dark purple. The explanations offered in the original article are plausible, but the same results may be produced in other ways which are equally plausible, and the difficulty is to decide the actual way in which it is produced, and not how it may be done. As a general rule, arterial blood has a bright scarlet tint, while venous blood is a dark red. The difference is most marked in individuals which have a slow or weak respiration, or dwell in cold climates; and it is least marked in those which have an unusually active respiration or dwell in warm climates. The florid hue is most extensive wherever the largest amount of oxygen has been absorbed. If all the gases be withdrawn from the blood, both the arterial and venous varieties present the same dull black tint. The colour is due to the red corpuscles and the changes they undergo. Although they are so minute, their superficial area is surprising, but it is difficult to estimate it. Vierordt has calculated that a cubic centimetre of human blood contains no fewer than 5,055,000 red corpuscles, and Welcker 4,600,000. Taking the former as a basis, it would yield upwards of 83 millions in every cubic inch, and if we estimate the whole quantity of blood in the system at 15 lbs. or a gallon and a half, it would give upwards of 38,445,000,000 red corpuscles for the whole body. Their total superficial area would be between 50 and 60 square feet. 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If, for instance, arterial blood be deprived of a portion of its fibrin, and be diluted with water, it acquires the aspect of venous blood; and the red colour may be restored by the action of a saturated solution of a neutral salt, while oxygen is unable to do it. Venous blood may be reddened by means of a similar saturated solution, but carbonic acid will not render it dark again. Hence it is not safe to conclude that the light or dark colour always indicates the relative abundance or scarcity of oxygen and carbonic acid gases. The changes of colour in the above illustration appear to be regulated by variations in the density of the fluid surrounding the corpuscles. When its specific gravity is lessened by the addition of water, the corpuscles are darkened, but when it is increased by the addition of a strong solution, they become lighter. That such variations do take place in the density of the liquor sanguinis is well known, but it remains to be proved whether such changes are the real agents. The following remarks by Dr. Carpenter especially apply to this point. "The blood contained in the veins of muscles is dark, and always of a deeper shade in proportion to the energy and duration of the previous muscular contraction, whilst that returning from the gland is always brighter in proportion to the activity with which secretion is being formed; and in the latter instance, with the alteration in colour, the amount of fibrin is found to be diminished, or so modified as to form a softer clot, from which a large quantity of serum separates. It is remarkable that if the dark coloured clot of ordinary venous blood be immersed in the serum of the scarlet venous blood, it rapidly assumes a brighter tint, and conversely the clot of scarlet venous blood changes to a dark colour when immersed in the serum of deep coloured venous blood; from which we may conclude that the primary changes are effected upon the liquor sanguinis, and not upon the corpuscles." Professor Stokes has examined the blood with the spectroscope, with a view to ascertaining what are the colouring matters, and in what way the transition from the purple to the scarlet hue is effected. He details a series of observations from which he infers that "the colouring matter of the blood is capable of existing in two states of oxidation, distinguishable by a difference of colour, and by a fundamental difference in the action on the spectrum. It may be made to pass from the more to the less oxidized state by the action of suitable reducing agents, and recovers its oxygen by absorption from the air." This colouring matter, in its two-fold state, he terms purple and red cruorine. This substance is exceedingly unstable in its nature, so that while it will take up oxygen greedily it parts with it again readily, and it is easily decomposed. Amongst the products of decomposition is hæmatin, which is far more stable, but otherwise it has considerable resemblance to cruorine in some of its chemical features. In order to illustrate what may be the functions of cruorine, Prof. Stokes describes an experiment, and offers comments upon it. A solution of protoxide of tin was rendered alkaline, and to it was added some tartaric acid. When some of this was added to a moderate quantity of a solution of scarlet cruorine, the latter was reduced, but was again oxidized by being shaken up with air. On standing for about two minutes it was again reduced, and could be reoxidized by further agitation with air. It thus appears "that purple cruorine absorbs *free* oxygen with much greater avidity than the tin solution, notwithstanding that the oxidized cruorine is itself reduced by the tin salt." His comments are to the following effect:—"As the purple cruorine in the solution was oxidized almost instantaneously on being presented with free oxygen by shaking with air, while the tin salt remained in an unoxidized state, so the purple cruorine of the veins is oxidized during the time, brief though it may be, during which it is exposed to the air in the lungs, while the substances derived from the food may have little disposition to combine with free oxygen. As the scarlet cruorine is gradually reduced, oxidizing thereby a portion of the tin salt, so part of the scarlet cruorine is gradually reduced in the course of the circulation, oxidizing substances derived from the food or of the tissues. The purplish colour now assumed by the solution illustrates the tinge of venous blood, and a fresh shake represents a fresh passage through the lungs." ('Proceedings of the Royal Society,' vol. xiii.) The quantity of red corpuscles may vary considerably within the limits of health, and still more widely in diseased conditions of the body. On the average it is greater in males than in females

by from 1 to 2 per cent.; in the higher vertebrates than in the lower; and in individuals of a sanguineous than in those of a lymphatic temperament. In anæmia, chlorosis, scurvy, albuminuria, and other diseases, there is a decrease of the corpuscles from the normal abundance. Considering that the blood is entirely confined within a system which has no direct communication with the open air, any information that gives the slightest clue as to the method of its formation is of importance. In this connection, then, we would mention Dr. Roberts' experiments on the corpuscles. On treating them with a solution of magenta the pale variety was more deeply tinted than the dark, and its nucleus was conspicuous on account of the bright carbuncle red which it acquired. These nuclei were observed to be in various stages of division, and were seen to liberate secondary nuclei, which passed into the blood, and by subsequent enlargement, change of form, and chemical composition, to develope into red blood-disks. By treatment with carbolic acid the corpuscles appeared as though their contents had separated themselves from the corpuscular wall, and had collected among the nuclei.

The red corpuscles consist of an albuminous base, or globulin, and of certain colouring matters. Bojanowski recognises four varieties, which he calls hæmatoglobulin, hæmatoidin, hæmatin, and hæmin; but our ideas concerning them are far from being precise, and it is probable that all the different varieties of colouring matter are variable mixtures of two definite compounds. The hæmatoglobulin may be obtained in crystals from blood which has been long exposed to cold air, but their shapes vary in different animals. They will dissolve in water, acetic acid, and ammonia, but not in alcohol. There is a marked difference in the crystalline varieties of this substance. Those of man will dissolve in 94 parts of water, while those of the guinea-pig require 600 parts for solution. The analysis of three specimens afforded Lehmann the following results:—

Carbon . . .	55·41	55·24	54·18
Hydrogen . .	7·08	7·12	7·14
Nitrogen . . .	17·27	17·31	16·40
Sulphur . .	·25	·21	·25
Oxygen . . .	19·99	25·12 (? 20·12)	20·03 (? 22·03)
	100·	100·	100·

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It may be made to pass from the more to the less oxidized state by the action of suitable reducing agents, and recovers its oxygen by absorption from the air." This colouring matter, in its two-fold state, he terms purple and red cruorine. This substance is exceedingly unstable in its nature, so that while it will take up oxygen greedily it parts with it again readily, and it is easily decomposed. Amongst the products of decomposition is hæmatin, which is far more stable, but otherwise it has considerable resemblance to cruorine in some of its chemical features. In order to illustrate what may be the functions of cruorine, Prof. Stokes describes an experiment, and offers comments upon it. A solution of protoxide of tin was rendered alkaline, and to it was added some tartaric acid. When some of this was added to a moderate quantity of a solution of scarlet cruorine, the latter was reduced, but was again oxidized by being shaken up with air. On standing for about two minutes it was again reduced, and could be reoxidized by further agitation with air. It thus appears "that purple cruorine absorbs *free* oxygen with much greater avidity than the tin solution, notwithstanding that the oxidized cruorine is itself reduced by the tin salt." His comments are to the following effect:—"As the purple cruorine in the solution was oxidized almost instantaneously on being presented with free oxygen by shaking with air, while the tin salt remained in an unoxidized state, so the purple cruorine of the veins is oxidized during the time, brief though it may be, during which it is exposed to the air in the lungs, while the substances derived from the food may have little disposition to combine with free oxygen. As the scarlet cruorine is gradually reduced, oxidizing thereby a portion of the tin salt, so part of the scarlet cruorine is gradually reduced in the course of the circulation, oxidizing substances derived from the food or of the tissues. The purplish colour now assumed by the solution illustrates the tinge of venous blood, and a fresh shake represents a fresh passage through the lungs." ('Proceedings of the Royal Society,' vol. xiii.) The quantity of red corpuscles may vary considerably within the limits of health, and still more widely in diseased conditions of the body. On the average it is greater in males than in females

by from 1 to 2 per cent.; in the higher vertebrates than in the lower; and in individuals of a sanguineous than in those of a lymphatic temperament. In anæmia, chlorosis, scurvy, albuminuria, and other diseases, there is a decrease of the corpuscles from the normal abundance. Considering that the blood is entirely confined within a system which has no direct communication with the open air, any information that gives the slightest clue as to the method of its formation is of importance. In this connection, then, we would mention Dr. Roberts' experiments on the corpuscles. On treating them with a solution of magenta the pale variety was more deeply tinted than the dark, and its nucleus was conspicuous on account of the bright carbuncle red which it acquired. These nuclei were observed to be in various stages of division, and were seen to liberate secondary nuclei, which passed into the blood, and by subsequent enlargement, change of form, and chemical composition, to develope into red blood-disks. By treatment with carbolic acid the corpuscles appeared as though their contents had separated themselves from the corpuscular wall, and had collected among the nuclei.

The red corpuscles consist of an albuminous base, or globulin, and of certain colouring matters. Bojanowski recognises four varieties, which he calls hæmatoglobulin, hæmatoidin, hæmatin, and hæmin; but our ideas concerning them are far from being precise, and it is probable that all the different varieties of colouring matter are variable mixtures of two definite compounds. The hæmatoglobulin may be obtained in crystals from blood which has been long exposed to cold air, but their shapes vary in different animals. They will dissolve in water, acetic acid, and ammonia, but not in alcohol. There is a marked difference in the crystalline varieties of this substance. Those of man will dissolve in 94 parts of water, while those of the guinea-pig require 600 parts for solution. The analysis of three specimens afforded Lehmann the following results :—

Carbon . . .	55·41	55·24	54·18
Hydrogen . .	7·08	7·12	7·14
Nitrogen . . .	17·27	17·31	16·40
Sulphur . .	·25	·21	·25
Oxygen . . .	19·99	25·12 (? 20·12)	20·03 (? 22·03)
	100·	100·	100·

Notices of hæmatoglobulin will be found under HEMATOCYSTALLIN, E. C., A. AND SCI. DIV.; of hæmatin, under HEMATOSIN, in the same division; and of hæmatoidin under the same name in that division. Of hæmatoidin we will only say here, that it is probably formed from hæmatin by decomposition. Hæmin occurs in rhombic crystals, those of men being readily distinguished from the crystals yielded by the blood of domestic animals, and hence their form is frequently employed as a test of the character of blood-stains in medico-legal inquiries. They are of dark brown or black colour, but are rendered violet by oxygen, and again opaque by subsequent treatment with carbonic acid. Globulin, which forms the great bulk of the corpuscle, is a modified form of albumen, and has the same percentage composition. The analyses given by Lehmann of hæmatoglobulin are identical with the results afforded by globulin. Globulin is the albuminous constituent of the corpuscle, and represents the albumen of the liquor sanguinis.

We now pass from the corpuscles to consider the fluid in which they float. It is a solution, the constituents of which are liable to constant change within certain narrow limits. Amongst those constituents we have mentioned fibrin, but it is not certain that this substance pre-exists in a state of solution. It has been suggested that when it separates from the blood, forming the well-known phenomenon called coagulation, it is then formed for the first time from two substances already existing in the blood. In the E. C. article the fibrin is said to be mechanically suspended in the blood, but this is certainly not the case. Coagulation has been much studied, but although inquirers appear to be approaching the truth as to the causes which produce it, and its significance as throwing light upon the formation of the blood, they have yet far more to learn. Coagulation is for the most part the result of a combination of circumstances external to the body itself. When the blood is withdrawn from the system, and exposed to the air, the corpuscles begin to sink, while minute fibres form in the fluid, beginning at the sides of the vessel at the surface, and creeping towards the centre. This proceeds so rapidly in most cases that the fibrin entangles many of the corpuscles in its meshes, and so forms the clot. The coagulum is a fibrous solid, especially remarkable since it presents an arrangement analogous, or probably identical in character with that of organized structure, and the resemblance is greatest when highly vitalized fibrin coagulates very slowly on a living membrane, and produces a fibrous tissue with blood-vessels traversing it. It only differs from the tissue formed *within* the living organism in being less distinctly fibrous. With regard to the time mentioned in the E. C. article which the clot takes to form, it is true for the majority of cases, but it is by no means constant. It takes a very long time in individuals which have been killed by lightning, electric shocks, and asphyxia, and it may be retarded or accelerated in various ways. Many facts are on record which support the hypothesis that fibrin is the result of the combination of two distinct substances, and this hypothesis has received considerable support from the researches of M. Alexander Schmidt, of Dorpat, an analysis of which is given in the 'Natural History Review' for 1864. For instance, by adding the serum of blood (a fluid which presents no tendency to coagulate, and which is supposed to be perfectly free from fibrin, since that has been thrown down in the blood clot) to any other serous fluids which themselves do not possess any power of spontaneous coagulation, we obtain a clot of fibrin. The serous fluids are believed to be coagulable by themselves soon after withdrawal from the living body, but they soon lose their power. The power is at once restored to them by the addition of blood serum. From this it would seem that the two fluids possess, when combined, some condition which is wanting in their separate states. Blood serum has a very feeble coagulating power, and it has been disassociated from the fibrin and the corpuscles. The addition of fibrin to it has no effect; but if only a few corpuscles be added, its coagulation is greatly increased, and if a microscope be employed, the corpuscles will be seen to be the centres of the coagulating force. The blood crystals, termed hæmatoglobulin, have a similar coagulating power. Schmidt supposes that the blood corpuscles contain a constituent which, combining with another in the serum, forms fibrin. Accordingly he groups all substances which act like the corpuscles as *fibrinoplastic* agents, and those which behave like serum *fibrinogenous*—terms which may be used for these ideas without implying the existence of any substance known as *fibrinoplast* and *fibrinogen*, as Schmidt does. On passing carbonic acid through fibrinoplastic fluids globulin is obtained, which forms the essential part of corpuscles and blood crystals, and which is regarded by Schmidt as one of the constituents of fibrin. It is found in all the coagulative fluids, such as the aqueous humour, saliva, synovia, connective tissue, and elsewhere. Globulin loses its fibrinoplastic powers when long exposed to the air, or subjected to a temperature of 158° F.; but they are increased by an alkaline solution just sufficiently strong to dissolve it, while it is weakened or destroyed in stronger solutions. An acid solution masks its powers, so that the stronger it is the larger is the quantity of alkali required to counteract the acid, and to restore the powers. It appears, however, to be necessary that the globulin should be in some particular condition about which nothing is known. Having found, as he thought, one of the constituents of fibrin, Schmidt applied himself to the discovery of the other. He saturated a fibrinogenous liquid with carbonic acid, and obtained a substance which was found to give a clot with blood serum. It resembled globulin in its general behaviour towards reagents, but differed as regards its sensitiveness towards them, being more easily precipitated from its solutions by alcohol. There was, however, still something wanting, for when the prepared fibrinogenous and fibrinoplastic fluids were mixed, it was seldom a coagulum could be obtained, and then only an imperfect one. This last difficulty will, no doubt, be removed when some one undertakes a complete examination of the causes which induce the formation of the numerous albumen and albumen-like compounds. The result of this part of the inquiry is summed up by the writer of the article in the 'Natural History Review' in the following terms :—"All fibrinoplastic substances are found to contain globulin. Deprived of their globulin, they lose their coagulating virtues. Globulin itself is highly fibrinoplastic; added to a fibrinogenous liquid it disappears, giving rise to fibrin. By no other means than by the action of a fibrinogenous liquid can globulin, so far as is yet known, be converted into fibrin. All fibrinoplastic liquids are found to contain a substance called fibrinogen. Deprived of their fibrinogen, these liquids will no longer coagulate on the addition of globulin. Fibrinogen added to a fibrinoplastic fluid disappears, giving rise to fibrin. By no other means than by the action of a fibrinoplastic fluid can fibrinogen be converted to fibrin. Though the direct union of fibrinogen and globulin rarely succeeds in giving rise to fibrin, yet the two bodies obtained together by the action of carbonic acid or plasma produce a clot when dissolved in a feebly alkaline fluid." With the help of these preliminary, perhaps hypothetical views, the consideration of the action of various agents on the coagulation of blood will be more easily understood. They act mainly in retarding or hastening the coagulation, in increasing or lessening the quantity of fibrin formed, and in modifying the character of the clot as regards consistency, &c. Dilution with water retards it, and may even prevent it, if a large quantity of water be used. Since fibrin is quite insoluble in cold water, the addition of more water would be expected rather to hasten the coagulation, if it were simply the release of the fibrin from its solution; while, if it were the result of a chemical combination, dilution would be expected to weaken the energy of the combination. So, again, heat quickens the process, while cold delays it, but a temperature of 158° stops it. At this temperature globulin is known to undergo a slight modification prior to passing into its insoluble form at higher temperatures. Carbonic acid is sometimes favourable, and sometimes unfavourable, to coagulation. It is favourable when the fluid is highly alkaline, and unfavourable when the fluid is otherwise in the best condition for the process to take place. In the latter case it reduces the albuminous substances to an insoluble condition. The action of air or oxygen is generally favourable, but in such cases it appears to arise from the displacement of carbonic acid when too abundant. The alkalies have a powerful influence, but are apparently very capricious, since they sometimes delay and sometimes hasten coagulation. It seems that coagulation will only take place in alkaline solutions of a certain strength, and that if they be already sufficiently alkaline, the addition of more retards or prevents the process, while, if they are acid, the addition of an alkali will promote it.

But still there remains the question, why does not fibrin form in the living body? Dr. Richardson says it arises from the fibrin being held in solution by the presence of ammonia, and that when circumstances, such as exposure to air, favour the escape of the volatile alkali, coagulation sets in. This hypothesis is untenable, since it is now determined by the experiments of Thiry, Kühne, and Gamgee, that in healthy normal blood there is no free ammonia. The arguments used by Dr. Richardson that the circumstances which promote or prevent the evolution of a volatile alkali have a similar effect upon coagulation, and that such facts are strongly in favour of there being such an alkali present, prove nothing if it can be shown that the alkali is not present; and in most cases they bear a different interpretation, while in the remainder the statements adduced do not hold good under all circumstances. Thus he says coagulation and evolution of an alkali are alike prevented by exclusion from air or other gases, by temperatures below a certain degree, and by the vapour of blood; and are alike quickened by increase of temperature, exposure to air or vacuum, and agitation. As regards temperature we find that the coagulation is quickened up to a certain point, but beyond 158° it stops; but the evolution of ammonia would certainly not be stopped at that temperature. The exclusion of air is not a necessary condition either as an aid to or preventive of coagulation. Blood will not coagulate if exposed to the air while surrounded by living tissue, or when contained in an artificial capsule of fibrin; on the other hand it will coagulate, even in the vein of a living animal, around a thread which has been passed through, care being taken to exclude air. The vapour of blood does not always prevent coagulation, and when it does it has been found to contain ammonia. This, however, shows nothing more than that ammonia may act like other alkalies in preventing coagulation; but that is no proof that it is the efficient agent in normal coagulation. Indeed when liquor ammonia is added to blood it cannot be driven off by exposure to air, vacuum, or a temperature of 95° F., and has evidently become fixed. Coagulation is, however, at once brought about by partially neutralizing the ammonia with a little acid. Amongst other hypotheses may be noticed that proposed by Brücke, who believes the blood coagulates because it is deprived of something which is constantly being supplied to it from living tissue; by Lister, who believes that "globulin and fibrinogen will not unite to form fibrin unless by the mediation of ordinary matter, living matter being unable to perform any such function," ('Natural History Review,' 1864), and by John Hunter, whose opinion is, that the fluidity of the blood depends upon something in the blood vessels, and that coagulation occurs when that something is withdrawn. The opinions of Hunter and Brücke are probably very similar, although both are indefinitely expressed. The ideas thrown out by them are, we are disposed to think, the real clue to the theory of coagulation, but what that theory is, the present want of knowledge precludes us from expressing more precisely. The blood contains the fibrinogenous and fibrinoplastic fluids or elements. In passing through the blood-vessels it contains a slight excess of one or other of them; each is constantly undergoing consumption or change, and fresh supplies of each are as constantly being received. Under certain circumstances the relation between supply and consumption is so altered that combination is effected and fibrin is formed. Fibrin, it should be remembered, is being constantly formed or deposited in the body. It also undergoes decomposition, or rather, if the views of Schmidt be adopted, one or both of its constituents are modified in some way. Thus Brown-Sequard found that the blood going to the kidneys had a high coagulative tendency, while that which leaves it has little or no coagulative power. In passing through the kidneys as much as 8 or 10 lbs. of fibrin or fibrin-forming matter is deprived of the power of coagulation. The proportion of fibrin yielded by blood varies, being greatly increased in all cases of local inflammation; the increase is also well marked in acute rheumatism, and in the tubercular stage of phthisis. On the other hand it is much diminished in cholera. In describing the uses of fibrin in the system, Dr. Carpenter points out many other circumstances under which it is formed. He confesses we have but little positive knowledge as to the purposes of fibrin, but, "putting aside," he continues, "its presumed importance in maintaining that physical condition of the blood which is most favourable to its free movement through the vessels, and to its due retention within their walls, we find that it is entirely on the coagulating powers of the blood that the cessation of hæmorrhage from even the most trifling injuries is dependent; that the limitation of purulent effusions by the consolidation of the surrounding tissue, and the safe separation of gangrenous parts, can only take place in virtue of the same property; and that the adhesion of incised wounds, still more the filling up of breaches of substances, require, as their first condition, that either the blood or matter exuded from it should be able to assume the state of fibrous tissue. On the other hand we see the consequences of excess of the proportion of fibrin, and of that increased plasticity (or tendency to fibrinate) which usually accompanies its augmentation, in the tendency to form those plastic effusions which are characteristic of the inflammatory state, and which, if poured out upon serous or mucous surfaces, constitute 'false membranes' and 'adhesions,' or if infiltrated into the substance of living tissues, occasion their consolidation. This increased plasticity of the blood, however, may frequently be regarded in the light of an "effort of nature" to antagonize the evil consequences of that depression or positive destruction of the vitality of the solid tissues, which seems to form an essential part of the inflammatory condition; and thus it is that, whilst the central part of a tissue, in which the inflammation has been most intense, suffers complete death, and is carried away in the suppurative process, the peripheral part, in which the violence of the inflammation has been less, becomes infiltrated with plastic matter poured out from the blood, and forms the solid and impermeable wall of the abscess."

There is much analogy, nay, we might almost say identity, between the coagulation of blood and the condition of the muscles known as *rigor mortis*. The latter is the coagulation of certain albuminous substances, similar to but not identical physically with those found in the blood. And it is remarkable that blood and muscles have many properties in common, and that both contain the same decomposition products, such as *creatine*, *hypoxanthine*, &c.

Of the other constituents of the blood, such as the albumen, the salts, and the gases, we have left ourselves no room to say much. They undergo modifications of form and quantity. The albumen in the ordinary state has little or no power of passing through the walls of the blood-vessels, but under certain circumstances it passes readily through, and consequently the blood becomes impoverished in albumen, in which state it forms the diseases known as albuminuria and Bright's disease. The alkaline salts are increased in cases of severe inflammation, but diminished in many of the malignant diseases, such as cholera, owing in great measure to the large quantities of water which are then drawn off from the blood.

The changes in the proportion of the ingredients of blood have had reference to the body generally; but there is another branch of the subject which is of the highest importance in understanding physiological phenomena, but which has as yet not been systematically worked: a few examples of the kind of change we refer to will illustrate this remark. When an animal has been fasting for some time, the blood in the mesenteric veins does not differ from venous blood generally; but after a meal it undergoes a complete change. It becomes highly diluted with water, the albumen is much increased by fresh supplies of albuminous matter, and the corpuscles are decreased relatively, if not absolutely. The soluble organic matters, such as sugar, dextrine, &c., appear in it; the fibrin does not coagulate firmly; the albuminous constituent differs from true albumen in not being coagulable by heat or nitric acid, and in the ease with which it passes through animal membranes. It appears to be the same as the albuminous substance which occurs in blood in Bright's disease and in albuminuria, and to be the first stage of what is generally transformed in its further progress along the veins into true albumen. Malhe has named it *albuminose.* The fibrin is probably also modified into that form which gives a firm clot. Soon after the meal has been digested, the blood of the mesenteric vein gradually resumes the character which appertains to it generally in the venous system. In the blood of the spleen the red corpuscles are diminished in number, the albumen is much increased, and the fibrin still more so. The last sometimes reaches 11 parts in 1000, or far more than in any other portion of the blood. This blood is also remarkable for the extraordinary number of white or colourless corpuscles which it contains. The blood of the renal veins contains less water and less urea than that of the renal arteries, these substances having been separated from the system in the passage of the blood through the kidneys. Professor Lehmann has pointed out the principal differences in the blood of the portal and hepatic veins. The latter, he says, "is far the poorer in water; so that, assuming the solid constituents of the blood to be equal in both kinds of blood, the quantity of water in the blood of the portal veins is to that in the blood of the hepatic veins as 4 : 3 during digestion and when not much drink has been taken, and sometimes as much as 12 to 5 after digestion has been fully accomplished. The blood of the hepatic veins either does not coagulate at all, or the clot is bulky and readily breaks down. Whilst 34 parts of serum are separated from 100 parts of portal blood, only 15 parts are separated from 100 parts of the blood of the hepatic veins. The blood of the hepatic veins is far richer in blood-cells, both coloured and colourless, than that of the portal veins; the colourless corpuscles occur in the most varied shapes and sizes. Hirt estimated that the proportion of the colourless to the red corpuscles was, in the portal venous blood as 1 : 524; in the hepatic, as 1 : 136; the coloured are seen in heaps of a distinct violet colour, and their cell-walls are less readily destroyed by water than are those of the blood of most other vessels. The cells in the blood of the hepatic veins are poorer in fats and in salts, and especially in hæmatine, or at least iron, but somewhat richer in extractive matters. Their specific gravity is higher than that of the cells of the portal veins, notwithstanding the diminished quantity of iron. The plasma of the blood of the hepatic veins is far denser than that of the blood of the portal veins, for it contains a much larger amount of solid constituents generally, although little or no fibrin is to be found in it. If we compare the solid constituents of the serum of both kinds of blood, we find less albumen and fat, and far less salts, in the blood of the hepatic veins, while the quantity of extractive matter, including sugar, is perceptibly augmented." (Carpenter).

(Gulliver, G., *Proceedings of the Zoological Society*, 1862, pp. 91—103; Dr. Carpenter, *Principles of Human Physiology*, 6th edition; Watts, *Dictionary of Chemistry*, art. *Blood; Natural History Review* for 1864, pp. 156—187.)

BOGS [E. C. vol. i. cols. 528—532]. These remarkable accumulations of vegetable matter are of various kinds, and have originated in various ways, as will be presently described. Their history throws much light upon a particular period of geological time when, as it would seem, a striking change took place in the climate of many parts of the world, whereby the old forests were completely destroyed and their places occupied by marshes, lakes, and bogs. Their description also has its interest, since it enables us to understand what were probably the conditions which superinduced the formation of coal in the far-distant carboniferous epoch. So similar, indeed, are bogs or peat-beds to seams of coal, and so characteristic are peat bogs of the recent period of the geologists, that this period might be regarded as a second carboniferous epoch.

Peat, or the substance formed in bogs, is the product remaining after the slow decay of vegetable matter; but as such matter will give rise to other products by decay, it will be desirable to give a general outline of what becomes of dead plants under certain conditions. Plants are mainly formed from a few elements—namely, carbon, hydrogen, oxygen, nitrogen, sulphur, and phosphorus. These are obtained for the most part from carbonic acid, water, ammonia, and sulphuretted hydrogen, and are built up into the compounds of the plants by processes which effect the gradual partial elimination of the water and oxygen. In addition to these there are other compounds, consisting principally of silica and alkaline salts. The former group of compounds are entirely volatilized under the influence of heat, while the latter remain behind to form the ash, and hence the parts of a plant are roughly distinguished into those which are volatile, and those which are fixed. And in the study of peat bogs it is convenient to classify plants into those which contain nitrogen, and those which do not contain that element. The former are readily distinguished by giving either a faint odour like burnt potatoes, or none at all, when heated; while the latter emit the odour of burnt bones or feathers when similarly treated; and if decomposed, the nitrogenous compounds stink like rotten eggs if sulphur originally entered into their composition, and like rotting fish if phosphorus was one of their ingredients. For our purpose, however, the principal distinctive point is the presence or absence of nitrogen. When the plant dies it is converted more or less completely into gases and vapours, such as carbonic acid, water, ammonia, sulphuretted hydrogen, and phosphuretted hydrogen. The extent to which the conversion is carried depends partly upon external circumstances, and partly upon the original constitution and composition of the plant. Under one set of circumstances, such as a dry air, warm temperature, and a composition rich in nitrogen, the plant is almost entirely volatilized, and leaves little to represent it but the ashes or so-called inorganic parts; whereas under the opposite set of conditions, such as immersion in water, a cool or cold temperature, and a composition free from nitrogen, a large proportion of the carbon, hydrogen, and oxygen remains behind in a form which is stable under ordinary circumstances, and which has the inorganic parts mixed with it. In the former case the resulting product is almost entirely free from carbon, while in the latter it is highly carbonaceous. These two extremes are connected by intermediate gradations, which may contain from one to forty or fifty per cent. of carbon. Peat represents the most highly carbonaceous products. The compounds which are formed under these circumstances are too numerous to be even enumerated, but, according to Senft, the principal are *humin*, which is developed when the plant decomposes under the influence of a free supply of air; *ulmin*, which is formed when the supply of air is restricted; and *gein*, which originates when the air is excluded. These in their turn are readily converted into ulmic, humic, and geic acids, which unite with the alkalies to form numerous salts. By oxidation the humic and geic acids are developed into crenic and apocrenic acids, and these also form salts with the alkalies.

The changes which the plants undergo after death are generally similar, and take place for the most part in the same order. During their period of growth they gradually accumulate a covering or lining on the inner side of the walls of their cells, and after a time this becomes so thick as to hinder the free transpiration of oxygen and aqueous vapour from the inside to the outside of the cell. At this stage the plant generally begins to decompose, the contents of the cell disappearing first, next the cell membrane, and lastly the spiral fibres. The retention of the oxygen sets up a process of fermentation, especially in the nitrogenous compounds, and the products which are developed are ammonia, sulphuretted hydrogen, and phosphuretted hydrogen. The ammonia in its turn acts as a ferment on the non-nitrogenous compounds, such as the sugars and starches, which are converted into the various acids generally yielded by decaying vegetable matters. These acids unite with the ammonia. In course of time the cells become so distended with the products of decomposition that their walls burst, and the various gaseous compounds escape. The circumstances under which further chemical changes are now carried on are quite different, and a larger proportion of the vegetable matter which still remains unaltered is converted into the humic and allied acids, and carbonic acid, while the soluble compounds are more readily dissolved and carried away. The final result is that the cells are almost entirely deprived of their contents, and have lost their originally green colour. The next stage consists of the decomposition of the cell membrane, which proceeds more or less rapidly according as it is or is not combined with feebly soluble lime salts, silicates, and resinous matters, and according to the strength of the vegetable acid solutions in which it is immersed. By the evolution of oxygen, water, and carbonic acid, there results a mass which contains a large proportion of carbon, a little hydrogen, and a little oxygen, which is generally a yellow brown ulmin, but this is frequently afterwards converted by oxidation into the light brown humin. At this stage the vegetable matter is mainly a mixture of ulmin, humin, and spiral fibres. The last stage is much assisted by the combined action of frost and moisture. The frost breaks up the fibres, and the black mould-like substance greedily absorbs water and becomes so water-logged as to sink to the bottom of the pool in which it may be. Here it is subjected to pressure, undergoes a slow carbonization, becomes permeated with bituminous and resinous substances, and ultimately becomes what is known as peat. The rate at which the process proceeds, and the character of the resulting products, are more or less modified by the character of the original plant mass. The character of the season also has an important modifying influence: for humus results when the summers are hot, dry, and long, and the winters yield but little snow and frost; while peat thrives best when the summers are moist and the winters are severe, that is, those in which frosts and snowstorms are prevalent. The extent to which the ground is wooded also has an influence, for peat will flourish under the shades or amidst the damp airs of forests, whereas if those forests were destroyed it would grow less rapidly, or perhaps even cease to grow at all. Senft recognizes ten different kinds of peat, five of which he groups together under the appellation of felty peat (*Filztorf*), in which the vegetable fibres are still distinguishable; while five are grouped together under the term peat proper, or peat-coal (*Torfkohle*). Minute descriptions and analyses are given of all these in the work cited below. Indeed Senft's labours are an invaluable assistance in all matters connected with bogs and peat.

Observers have recognized several different kinds of peat bogs, dependent on variations in locality, altitude, humidity, &c.; but these may be conveniently classed in two groups, viz., those which grow on moist ground, generally in elevated positions; and those which form in lakes or large bodies of still, but not stagnant, waters. These groups are generally recognized by writers, but each author has his own names for them. Lesquereux calls them immersed and emerged bogs. The immersed bogs are generally met with in the lowlands, wherever the temperature is sufficiently cool, and where the water collects in shallow depressions. In the pools and lakes various species of *Equisetum*, *Carex*, and *Arundo* flourish, form a dense vegetative growth round their margins, and on decaying form a layer of peat. Peat, however, is only formed so long as the water is clear and still; and if a sudden inundation occur, giving rise to strong currents, together with deposits of sand and clay, the process is stopped until tranquillity is restored. Hence peat does not occur in flowing rivers, and when it originates in river bottoms it is due to the river having become so low as to consist of a series of pools connected by small rivulets of water. Peat, moreover, is only met with on soils which are impermeable to water. From these causes the peat bogs appear to be somewhat indiscriminately distributed. For of two contiguous river valleys one may contain peat bogs and the other be free from them, although the climate may be apparently identical. Thus, for example, peat occurs in the valley of the Somme, which flows over an argillaceous bottom, and is seldom flooded to any very great extent, while this substance is absent from the valley of the Seine, in which the river flows over a sandy bottom. There are a few instances in which peat has been formed on sand, but such cases have proved to be exceptions in appearance only, for the sand has been a thin layer only, and has been immediately underlain by clay. A large proportion of the peat of England, Ireland, North France, North Germany, and the countries which surround the Baltic, originated in immersed bogs. The Irish bogs are described by Mr. Moore as red, brown, black, and mountain bogs, but the great proportion of them belongs to what he calls the red bogs. The colour is due to the abundance of oxides of iron, a feature which may be regarded as accidental and of minor importance. They have, probably, been formed in extensive sheets of water in the midst of forests. Their central portions are almost entirely composed of the remains of such plants as *Narthecium ossifragum*, *Eleocharis cæspitosa*, *Carex stellulata*, *Schænus nigricans*, *Erica tetralix*, and *Myrica Gale*. In the interspaces left by these, such genera as *Sphagnum*, &c., flourish, while the higher and drier tufts are occupied by *Menyanthes trifoliata*, *Comarum palustre*, and *Eriophorum angustifolium*. *Sphagnum* forms the great bulk of the bog; but Mr. Moore says its growth is favoured by the presence of the other plants. A general feature of this class of bogs is the absence or rarity of the remains of trees.

The emerged or mountain bogs do not grow in water, but in moist places, and sometimes even on the slopes of hills. The peat forming them is strongly absorbent of moisture, so that they are frequently underlain by a thin sheet of water, which, on the occurrence of heavy showers of rain, is so increased in bulk that the bogs burst and flow to lower levels. This kind of peat frequently contains buried trees, the species of which vary at different levels, although not always in the same order in contiguous countries. The genus *Sphagnum* also enters largely into this description of bog, but in some places this genus is replaced by others. Thus in Ireland, according to Mr. Moore, the more elevated mountain bogs are chiefly formed by the grey moss *Thacomitrum lanuginosum*, while *Sphagnums* are rare. And Darwin long ago noticed that the peat of the Falkland Islands and other parts of South America is mainly composed of *Astelia pumilum* and *Donatia magellanica*. The flora of the bogs of Europe is composed of species belonging to widely separated families. There are upwards of 50 species of non-flowering or cryptogamous plants, amongst which are 35 species of mosses, while there are also representatives of the *Hepaticæ*, *Confervæ*, ferns, and horse tails. The monocotyledons are 36 in number, and the dicotyledons 21; but none of the last forms any large proportion of the peat. The general character of the flora is the same in Europe, Asia, and America. There are a few species in the north of Europe which are rare or absent in the bogs of the south. The *Paludella squarrosa* is rare in the bogs of the Jura mountains, but plentiful in districts farther north. A similar remark especially applies to *Splachnum*. The *Erica vulgaris* of the Jura bogs is represented by *E. tetralix* in more northern bogs; while *Arbutus uva-ursi* and *Empetrum nigrum*, which are bog plants in the north, have only been met with in the Jura mountains at elevations above that at which peat will grow. The floras of the bogs of Europe and North America are generally similar, and indeed a large proportion of the species are identical. This will be seen from the following list given by Leo Lesquereux, in which the species common to both continents are marked with a star. In North America the peat is mainly formed by:—

* Sphagnum cymbifolium. Ehr.
* S. squarrosum. W. & M.
* S. recurvum. Ehr.
* S. cuspidatum. Ehr.
* S. compactum. Bred.
* S. contortum. Schults.
* Dicranium Schraderi. W. & M.
* D. palustre. Br. & Sch.
* Meesia longiseta. Hed.
* M. tristicha. Br. & Sch.
* Aulacomnium palustre.
* Hypnum trifarium.
* H. stramineum. Dick.
* H. nitens. Hedw.
* H. cordifolium. Hedw.
* H. stellatum. S.
* H. fluitans. S.
* H. aduncum. S.
* H. scorpioides. S.

H. paludorum. F.

Of these all but the last abound in European bogs. The following species grow in the bogs of both continents, but do not contribute materially to the formation of peat.

* Splachnum ampullaceum. S.
* Polytrichum gracile.
* Dicranium cerviculatum. Hed.
* Hypnum cuspidatum. S.
* H. pratense. Koch.
* H. filicinum. S.

The ferns found in the American marshes include:—

Woodwardia Virginica. Willd.
* Dryopteris thelypteris. Adans.

D. noveboracensis. Adans.
* D. cristata. Adans.

Osmunda spectabilis. Willd.
O. Claytoniana. S.
O. cinnamomea. S.
* Ophioglossum vulgatum. S.
* Lycopodium inundatum. S.
* L. clavatum.

The grasses found in the American marshes are:—

Narthecium Americanum.
• Juncus effusus. L.
• J. maritimus. L.
• J. acuminatus. Mich.
J. molitaris. Bigel.
• J. stygius. L.
• J. bufonius. L.
Xiris bulbosus. Kunth.
• Eleocharis palustris. R. Brown.
• Scirpus cæspitosus. L.
• S. pungens. Vahl.
S. Torreyi. Oln.
• S. lacustris. L.
• Eriophorum alpinum. L.
• E. vaginatum. L.
• E. gracile. Koch.
• Rhynchosporon alba. Vahl.
R. capillacea. Torrey.
Cladium maris-cordis. Torrcy.
• Carex dioica. L.
• C. pauciflora. Light.
C. polytrichoides. Muhl.
• C. teretiuscula. Good.
• C. paniculata. L.
• C. chordorhiza. Ehrh.
• C. gracilis. Ehrh.
C. trispina. Der.
• C. stellulata. Good.
• C. limosa. S.
C. irregula. Smith.
• C. Buxbaumii. Wahl.
• C. filiformis. L.
C. lanuginosa. Mich.
C. folliculata. L.
Leersia oryxoides. Smith.
L. virginica. Willd.
Glyceria Canadensis. Trim.
G. nervata. Trim.
G. aquatica. Smith.
• G. fluitans. R. Brown.
• Phragmites communis. Trim.

There may also be found in the American marshes and bogs:—

• Typha latifolia.
• T. angustifolia.
• Abies alba nuchæ.
Larix Americana. Mich.
Taxodium distichum.
Nymphæa odorata.
• Nuphar lutea. Smith.
Sarracenia purpurea. S.
• Viola palustris. S.
• Drosera rotundifolia. S.
• D. longifolia. S.
• Parnassia palustris. S.
Sanguisorba Canadensis. S.
• Comarum palustre. S.
• Vaccinium oxycoccos. S.
V. macrocarpum.
• Chirogerus hispidula. Torr.
• Andromeda polifolia. S.
• Veronica scutellata. S.
• Scutellaria galericulata. S.
• Calla palustris.
• Scheuchzeria palustris. S.

The greatest difference is presented by the orchids, of which 70 per cent. only are common to the two continents.

The peat bogs are mainly developed in the temperate and subtemperate zones; and their abundance and rate of growth is chiefly regulated by the temperature and humidity. If two places have the same mean annual temperature, that which has the moister climate will be the more favourable locality. Peat bogs are almost unknown to the south of the 45th degree of north latitude in Europe, and in the more southern localities, as in the Pyrenees and central France, and many parts of Germany, they are most abundant at considerable elevations. But they disappear at a certain height, which in the Alps is about 6000 or 7000 feet. In the southern hemisphere the limit is in a corresponding latitude, peat being unknown, or at any rate very rare, to the north of 45° S. lat. Peat bogs are absent in both the arctic and antarctic circles. According to Lesquereux, the most favourable temperature for the immersed bogs is where the mean of the year is between 43° and 46° F., which is said to be the temperature of the places where peat is most abundant, such as Ireland and the high Jura valleys in the northern hemisphere, and the Falkland Islands in the southern hemisphere. The emerged bogs flourish best where the mean annual temperature varies from 40° to 46°, and are of rare occurrence where the mean is as high as 50°. The mountains and valleys of Ireland, the chains of central Europe, the Cevennes, the Vosges, the Jura, the Black Forest, the Hartz, and the Alps, are the principal European localities for this kind of bog. We believe, however, the mean temperature most favourable for peat bogs is somewhat lower than stated by Lesquereux, for although the localities mentioned may now have the temperatures named, and may have the greatest thickness of peat, yet there are reasons for believing that the growth of peat is much slower now than formerly, and that in some places it has almost, if not quite, ceased, even in places as far north as the 53rd or 54th degree of north latitude. The change, however, seems to have been more dependent upon the general humidity than upon the temperature. But not only has the peat ceased growth in many parts of its more southern extension, but, as will be presently shown, it is actually decaying away. Moreover, there can be very little doubt in the case of emerged bogs, that there were times when a large proportion of the peat was forming far more rapidly than it does now. This question as to how fast peat grows has acquired considerable importance since it has been made the basis of calculations as to the antiquity of prehistoric relics. Under MAN, E. C. S., a case is cited in which 36,000 years is the time allowed for the growth of 30 feet of peat in the valley of the Somme. The calculation is based upon the assumption that the peat of that valley has been growing as fast since the time of the Romans as it did before. We do not assert that the assumption is false, but we have seen no proof that it is consistent with truth, and there are circumstances which indicate that we ought to pause before making it the basis of any important conclusions. This caution is the more especially necessary since there are strong grounds for believing that the reign of peat in Western Europe has long been on the wane, and that the present rate of the growth of peat does not represent its average rate in past times. The truth seems to be that the Somme peat is now scarcely growing at all; that there are localities where peat is now growing much faster; and that in former times its growth was more rapid than now. But, after all, the rate of growth depends so much upon circumstances which are ever varying, that no conclusions should be accepted if based upon rigid calculations, unless they harmonize with what is known from other sources. The lacustrine peat probably grows more slowly on the average than mountain peat, while its rate will be less influenced by variations in the humidity of the atmosphere. Lesquereux thinks the peat during the first part of its existence rarely grew less than 25 inches in a century, and that it may have at times attained a rate of 50 inches in the same space of time. The peat of the Somme, according to the same authority, probably grew at the rate of 11 feet in a century, or nearly an inch and a half in a year. The peat of the Swiss bogs grows at the rate of two inches per year, but this is afterwards reduced to one inch by compression. That even the greatest of these rates is not exceptional or beyond the bounds of probability is shown by the observations of other persons. De Luc says he saw peat grow 6 feet in 30 years; Hoffman reports an increase of 8 feet in 50 years; and other illustrations of the same kind might be cited; but in most of them the observations are made upon the rate at which holes in peat have been filled up, which, however, is not the same thing as the natural upward growth of a bog; and hence these observations are not to be relied upon except in showing how fast holes may be filled up. But we are not entirely without some means of forming a rough estimate of the rate of growth of the earlier layers or bands of peat. As has been already stated they contain trunks of trees. Some of them are three or four feet in diameter. If a trunk of this size is now exposed on the ground, it will rot away after the lapse of a certain number of years, depending upon the kind of wood. Under ordinary circumstances this process would occupy from twenty to forty years, assuming of course it simply decayed away. If it was attacked by larvæ it would crumble down in perhaps four or five years. If the peat bog period was, as we believe, a period of great moisture, this would in some circumstances have retarded the decay of the trunk, and at the same time hastened the growth of the peat. Are any illustrations on record to show whether modern peat bogs are able to bury trunks, and if so, the time they have taken to do it? Two illustrations, but not very apt ones, occur to us. When the wood of Drumlanrig was overturned in 1756, the trees were left on the ground. No peat moss was formed, but the trees rotted away into a vegetable mould. In the Swiss bogs, however, small trunks which have fallen on the surface of the peat are buried in about three years.

There are thousands of trees in the old bogs, and they present all stages of decay. Many of them have lost their upper third or upper half, showing that decay had attacked the wood before the peat could cover it; but there are also many instances of logs which present but few signs of decay. Here we are alluding more particularly to mountain or emerged bogs, since sound logs form a large proportion of the whole number found in lacustrine bogs; a circumstance due to their immersion in water retarding their decay. In Porlock Bay there are examples of trunks embedded in peat, which trunks originally fell on a firm surface, and were probably freely exposed to the air. These facts show that three or four feet of peat may accumulate before a tree has had time to decay. If we assign fifty years as the time required for such decay, and probably it was very much less, then it would seem the peat may have grown at the rate of 8 feet per century when in its most flourishing condition. The peat of the Somme valley contains tree trunks, but surely they would not have remained undecayed for thousands of years, a supposition which is required if Boucher de Perthes' estimate of 1 inch per century is to be accepted ? Lesquereux's estimate of 11 feet per century seems to be more in accordance with truth. But it may be asked why should Boucher de Perthes' estimate be refused if the number of inches of growth of the peat since the time of the Romans, when divided by the number of years which have elapsed, indicates a rate of 1 inch per century ? The reply has already been given in part. But it may be further added, that it has to be ascertained whether the climate was the same then as now. If it was colder, or moister, or if the country was more woody, the growth of the peat would have been accelerated. That North France may have been both colder and moister is rendered not improbable by what we know of Scotland and the general climatal changes which have occurred since the later part of the post-pliocene period ; and we know that the country was formerly better wooded. The following remarks on the peat mosses of Scotland are mostly stated on the authority of Mr. Geikie, and they may be taken as applicable to the peat mosses of other countries. As is well known, Scotland is almost devoid of any natural forests ; and it is also known that many of those which are described in the ancient records have since disappeared. The peat mosses of the higher grounds are almost universally situated on the sites of ancient forests, as is shown by the stools of the trees remaining *in situ*. The trees include such species as the oak, pine, birch, alder, hazel, willow, ash, juniper, and others. Not only do they occur where trees of the same kind might still grow, but some of the species, such as the pine, occur at elevations considerably above the height to which they now attain ; while others, such as the oak, grew on places which are now beneath the sea-level. These oaks were as large as the finest specimens in existence, whereas at the present time the oak will scarcely grow near the sea-shore, and if individuals do obtain a footing, they are stunted in growth. The old woods evidently extended to greater altitudes than trees of any size will grow now, and they flourished over a wider superficial area than the present limits of Scotland. The old oaks certainly did not grow in the sea, so that the land must have been sufficiently elevated to raise the sites of the submarine forests above the level of the sea. But a still further elevation seems required, since it is only at some distance from the sea that oaks will attain their largest dimensions. When we examine the abundant evidence of forests having formerly overgrown the length and breadth of the land, and even a portion of what is now the sea-bottom, in the period immediately prior to the general growth of peat, and compare it with the present condition of things, one can hardly realise the immense difference. As Geikie remarks, " the Hebrides once had their groves of oak and pine ; the bleak Orcades and sterile Zetland once afforded them a genial soil ; the bare flats of Caithness, the storm-swept valleys of the Western Islands, the desolate moory tracts of Perthshire and the north-eastern tracts, the peaty uplands of Peebleshire and the borders, and the wilds of Carrick and Galloway, have each their relics of by-gone forests." The former extension of the forests over the present sea-bottom is not special to Scotland, but it is a general feature of North-Western Europe. All round the English, Welsh, Irish, French, and German shores there are innumerable examples of submarine forest beds, and the great majority of them lie beneath a covering of peat. So constant is this connection between the destroyed forests and the subsequent growth of peat that the mind immediately infers some intimate relation between the two phenomena. Some persons have said that the falling of the trees has interfered with the drainage, and thereby superinduced the growth of the peat. Admitting that a few fallen trees will intercept the drainage sufficiently to bring about the conditions favourable for the growth of the peat, this will only explain a very small portion of the phenomena. For, under such circumstances, we should expect the defect in one part of the forest would again be covered with trees before any large portion of the forest had disappeared ; but in the case of Scotland it would seem the forest was almost totally destroyed and was never renewed. The Romans are known to have destroyed some of the forests which are now covered with peat ; but the Romans could not have destroyed the forests of whole kingdoms ; and, moreover, it is certain that the general destruction of the forests took place before the advent of the Romans. Other persons have suggested that the trees were killed by the peat ; but there is nothing in the nature of peat innocuous to trees, and under favourable circumstances trees will grow on peat as well as other soils. Other persons again have suggested that the main agent which has produced the change has been an alteration of climate, which was unsuited to the growth of large trees, but highly favourable for that of peat. This last, we are inclined to believe, is the true explanation. The before-mentioned agents were subsidiary, but quite unable, either singly or combined, to produce the wholesale destruction of which we have the evidence. Geikie is one of the authors who attribute the destruction of forests, and the occupation of their sites by peat bogs, to change of climate. From the facts and arguments which he adduces, it would seem that after the deposition of the glacial marine beds, the British Isles were united with the Continent ; that during this period the pine and the oak flourished ; that, in consequence of the insulation of Great Britain, the weather became warmer, and the glaciers disappeared, giving rise to great lakes and swamps ; that, during this moist period the peat plants attained their maximum development, but owing to the great increase in the warmth and siccity of the air, their growth began to wane, while the trees have not had the opportunity of regaining their ancient territory. The geological period when this moist epoch prevailed may be gathered from POST-PLIOCENE, E. C. S. At the bottom of many of the peat mosses is a thin layer of a friable brownish substance, which is evidently the humus or mould which was formed from the decay of the leaves, twigs, and trunks of the trees of the old forests before the peat period. This fact is interesting, as showing that the forests flourished for a long time, and formed simply vegetable mould by their decay, which mould has been preserved by the overlying peat. One of the facts appealed to in support of the trees having been killed by the peat is that the stools are in many localities broken off at the same height, although those in other localities are of unequal heights. There is nothing to show that the peat plants and not the prevailing moisture and cold killed the trees. The trees would begin to suffer from the climate as soon as the bog-plants began to flourish ; the moist state of the ground, which favoured the plants, would be injurious to the trees ; the peat would grow pretty uniformly over a limited area, and while this growth was proceeding the upper parts of the tree would be gradually decaying and rotting. The peat would preserve that part of the tree which it enveloped, and hence when a violent gale of wind arose, most of the trees would snap off at the junction of the sound and decayed parts. If the trees were unequal in size, the largest would for the most part resist decay longest, and as the peat continued growing, it would creep farther up, and preserve a longer stool. Sometimes the decay has been slow, and the peat has grown so fast that whole trees have been buried erect in peat. Thus in the moss of Curragh, Isle of Man, there are trees standing upright with 20 feet of peat above them. Trees have been found under similar circumstances in some of the deepest of the continental mosses.

Geikie's remarks on the proofs of the cessation of peat growth in the drier parts of Scotland are so interesting and important that we venture to give a pretty full abstract of them, in many places using his own words. A glance at the aspect of the Scotch peat mosses will convince any geologist that this formation has not only ceased to spread, but is in most cases rapidly disappearing. The moisture which in former times afforded it nourishment and support has now become its chief enemy. Every shower of rain, every frost, gives fresh impetus to the decay ; and leaving altogether out of account the operations of agriculture, we can yet have no doubt that natural causes alone would in time suffice to strip the last vestige of black peat from hill and valley. These remarks might be illustrated by examples drawn from any peaty district of Scotland did space permit, but a general description of the appearance presented by dead peat is all that can be attempted. The surface of peat which has ceased to grow is usually covered with short scrubby heath and rusty grasses, but frequently in so sparse a manner that every here and there the black peaty mould peers through. Nay, in many cases, the decomposing mass lies exposed and bare, with not a tuft of heath or blade of grass to be seen. Peat mosses of this description are not confined to any particular locality or situation. They occur generally throughout the country, and may be found on hill tops, on hill sides, and in valleys. The peat of a hill top usually shows a most rugged and wasted aspect. (In a footnote it is stated that few regions show better proofs of the decay of hill peat than the Moorfoots and Peeblesshire hills. The summits of the Moorfoots may be described as a wide platform, or tableland, out of which valleys have been scooped by rivulets and streams. Standing on the shoulders of one of the hills of the Leithen water, we see stretching out before us what appears to be a widespread and undulating peaty plain. To the wanderer across those hill tops, the deception is often for some time complete, till of a sudden he finds himself on the bank of a green grassy bank, which slopes steeply down to a brawling stream, and again rises to a corresponding height on the opposite side. The peat stopping thus abruptly where the ground begins to descend, has the appearance from below of a black wall running continuously along the brow of the hill. This is especially conspicuous in the valley of the Leithen and its tributaries, and also at the head of the Luggate, the Heriot, and Gladhouse waters. The higher grounds of the border counties also show peat in every stage of decay. The same appearances characterise the flat-topped hills of Carrick, which overlook the broad undulating moors of Wigton and Kirkcudbright.) Innumerable winding gutters of various breadths intersect it in all directions. These widen as they approach the circumference of the peat towards the brow of the hill, where, at the outlets, they are often yards across. When the hill slopes have retained any of their peaty covering, it is usually still more cut than that on the hill top. These natural channels or drains are due to the wasting action of running water, assisted by winter's frosts. The peat is dead, and, like the upraised coral reefs of the South Seas, wears rapidly away at the touch of the atmospheric agents. Year by year the little channels are eating their way back into the heart of the peat, and the process of destruction has often been carried so far as to have left merely a few irregular-shaped segments of peat scattered here and there over the top of the hill. The peat of the lower grounds attains a much greater depth, and has less of a denuded and wasted aspect than that of the hilly region. In many spots, indeed, *Sphagnum* and other peat-forming mosses seem to thrive well. But wherever the slope of the ground suffices to create a drainage the peat crumbles away. Even where the peat occupies a hollow or plain where the drainage must be weak, the decay of the moss has often been observed making rapid progress. There are, perhaps, but few bogs in Scotland which do not exhibit what are known as *moss hags*, or holes usually filled either with soft black mud or dry peaty mould. These moss hags are the result of denudation, and increase in width by the gradual mouldering away of the surrounding peat. Sometimes a system of natural drains or gutters connects the different holes, but many of these show no apparent outlet, and the water collected in them escapes by slowly working through the moss, or by creeping outwards between the peat and the soil.

The peat mosses of Scotland are, then, only a wreck of what they have once been. The outgrowth of peat has ceased to be general. Here and there mosses continue to increase in sufficient abundance to form that substance, but this increase, such as it is, is far exceeded by the general decay. The peaty covering is almost everywhere full of holes and winding channels, a sure sign that the bogs have failed in the combat against the denuding powers of rain and frost. Their upper surface is no longer overspread with *Sphagnum*—a hard crust of heaths and grasses caps them instead. All this points to a decrease in the humidity of our climate. This decrease must have been very gradual. Year by year its influence would operate on those districts which have the smallest rainfall, and would be felt latest in those where the rainfall is greatest. Hence the largest display of peat is now on the west and south-west borders of Scotland, on the moister hill tops, and in the deepest valleys. The same may be said of England; while Ireland, which is well supplied with the Atlantic rain, still has a good show of growing peat. The Scotch mosses formerly covered a much wider area than they do now; and in both the east and west large mosses have disappeared or are fast disappearing. The peat on the top of the Lammermuirs, Moorfoots, the Peeblesshire hills, and other hilly districts in the same region, is evidently the remains of a broad peaty mantle, which at one time stretched down many of the hill sides, and was continuous with the mosses of lower levels. Segments of the old covering may still be seen lying on some hill sides, and looking as if they had broken off and slipped down from the wasting cap of peat on the tops of the hills. The river deposits of the same region show alternations of sand and clay, with peaty matter borne down from the hills into lower positions. In the peaty covering of hills the least ragged parts are on the sides facing the rainy winds. Thus in some cases the peat on the southern slopes is thick and continuous, while that on the north is scored and seamed with runnels. Drainage may have had some influence in promoting the diminution in the humidity of the atmosphere, but not much. The peat began to moulder away before the general adoption of drainage operations. The peat of southern countries is more consumed than that farther north, showing that probably the decay began in the south before it commenced in the north.

Before bringing this article to a close a few words must be said as to the similarity between peat bogs and coal beds. Both are, speaking generally, formed from vegetable matter which has grown on the spot. In both an impermeable flooring is an important accompaniment; the under clay of the coal beds being as constant as the argillaceous bottom of peat bogs. Both peat and coal are formed by a similar process, or at any rate, both represent a similar result, which is the concentration of the carbon of the vegetable matter caused by the partial withdrawal of the more volatile elements, hydrogen, oxygen, &c. Some peat from the bottom of the deepest layers presents a very near approach to coal in colour, lustre, and fracture. The plants in both have the same general character, that is, they are such as grow in damp localities or in water. In peat there are flattened tree trunks; and in coal there is frequently to be seen a thin streak of vascular matter extending for several feet, which appears to represent what was at one time the trunk of a tree. The alternation of coal with sand and clays, whether marine or fresh water, may be paralleled by alternations of peat with similar clays and sands; and even most of the stratigraphical peculiarities of the coal measures, such as the wedging out of sand, the coming together of two separate bands of carbonaceous matter, horses, &c., have their modern analogies, or as we believe homologies, in recent peat-bogs. The Down Holland moss described by Mr. Binney affords one illustration of the resemblance to which we have alluded. This moss is situated near Ormskirk, and is not far distant from the sea margin of Lancashire. It rests on the new red sandstone, at the upper or east end of the moss; the peat is of the ordinary black kind, shows but slight indication of vegetable structure, and is from two to three feet thick. It is supported by a layer of white sand, which in its turn rests on a blue or brown clay. Trunks of oaks, pines, and willows, lie prostrate in the peat near their stools, whose roots grow into the sand and clay. In proceeding northwards and westwards the peat gradually thickens as far as a small brook at the junction of the Barton and Flean brooks, where the peat is much saturated with petroleum; and farther towards the west it disappears under a covering of blown sand. The moss is in most places below the level of high-water mark at Formby. A boring near the most western accessible portion yielded the following data, the upper beds being placed first:—

1.	Black decomposed peat with scarcely any structure; the lowest part hard, and of a pitchy nature	8 in.
2.	Black peat, very moist, full of petroleum, and showing few traces of vegetable substance, except in the lower parts .	3 ft. 10 in.
3.	Soft blue silty clay	3 ft. 6 in.
4.	Dry mouldy peat; lower part reedy . .	4 ft.
5.	Blue silty clay	6 in.
6.	Blue sandy clay	3 ft. 6 in.

The upper peat increased towards the west and north-west, while the silty clay gradually thinned and disappeared towards the north and east. The clay was deposited by the sea that formerly flowed from the south near the bed of the present Alt, over Formby, Altcar, and part of Down Holland. By the shifting of the sands and the changes in the channel of the Alt, a sand bank was raised which shut out the sea from the lowlands near Formby, and stopped the drainage of the Barton and Flean brooks. After a time other changes took place which allowed of the temporary ingress of the sea whereby the silty clay was deposited. Again the sand bank shut out the sea, and aided in bringing about the conditions favourable for the upward growth of the peat. Phenomena such as these enable us to realize how it may have happened that marine animals, such as *Microconchus spirorbis*, a serpuloid annelid, attached its testaceous covering to the outside of fresh-water plants or terrestrial trees, as not unfrequently happened in carboniferous times.

(Senft, *Die Humus- Marsch- Torf- und Limonitbildungen als Erzeugungsmittel neuer Erdrindelager*, 1862; Geikie, J., *Transactions of the Royal Society of Edinburgh*, xxiv., p. 363; Lesquereux, Leo, *American Journal of Science*, Second Series, xxviii. p. 22; Moore, D., *British Association Reports* for 1857 (Notices), p. 97: D'Archiac, *A.*, *Paléontologie Stratigraphique*, 1$^{\text{ère}}$ Année, 2$^{\text{e}}$ Partie, 1864, p. 388.)

BOMBYCIDÆ [E. C. vol. i. cols. 556—558]. A Lepidopterous family, the limits of which have been reduced to far less proportions than is implied in E. C., and still it is remarkably rich in generic and specific forms. The genera may be enumerated by hundreds, a statement which at once shows how difficult it would be to give an outline of the many discoveries which have recently been made in the group. The greatest general interest attaches to the connection of these silk-producing moths with the silk industry of the world generally, but more especially of Europe, since the common silk-worm, *Bombyx mori*, has been so decimated of late years that at one time it was feared the breed would be exterminated. The threatened destruction of the silk-trade has drawn the attention and efforts of many as to the best way of meeting the difficulty, and these efforts have taken different channels, all aiming at the common good. Some have studied the diseases with a view of stamping them out; others have studied the laws of heredity with a view to generating a healthier breed; others have sought to utilize the larvæ already employed in extra-European countries; and some have even proposed to rear spiders in colonies and make dresses out of their silken webs. *The silk-worm moth* has long been held to mean *Bombyx mori;* but not only is it known that many species were formerly confounded under this term, but also that large quantities of silk have been obtained from other species. In Asia alone there are upwards of 40 species of silk-producing *Bombycidæ*, on the more important of which we may make a few remarks. *Bombyx mori*, Linn., inhabits China, Cashmere and Bengal, and produces the largest cocoon, and the best silk; it yields one crop every year. *B. sinensis*, Hutton, yields several monthly crops of cocoons, and is an inhabitant of China. *B. Crœsi*, Hutton, the *Madrassee* of Bengal, yields nine monthly crops of beautiful golden-yellow silk, but of late years the cocoons have degenerated in quality. *B. fortunatus*, Hutton, is cultivated under the name of *Dessee* in Bengal. *B. arracanensis*, Hutton, is cultivated in Arracan. *B. textor*, Hutton, an inhabitant of China like most of the species already named, is cultivated in Italy and France, the silk yielded by it being of a beautiful white colour. In Bengal it produces an inferior silk, but the caterpillars are there used by the natives as an article of food. *B. religiosæ*, Helfer, occurs wild in Assam, and feeds on the sacred peepul tree (*Ficus religiosa*), and yields a silk which is said to be as good if not better than that of *B. mori*. *Attacus Atlas*, Linn., inhabits the district from China to Ceylon, and produces a strong grey silk; it is believed that the Tusseh cloth is made from this silk. *Attacus Cynthia*, a species which ranges throughout large areas of China and India, is now well known as, perhaps, a likely substitute for the common silk-worm in Europe. It feeds on the *Ailanthus glandulosa*, and hence the art of rearing these larvæ has been called 'Ailanthiculture.' In China it has been cultivated for centuries, and has supplied fabrics to millions of people; and it is not improbable it may be an important source of the future supply of European silk. It was introduced into France in 1859, and has been successfully reared in the open air. *Antheræa Assama*, Helfer, occurs in Assam, Silhet, Ceylon. It is extensively cultivated in Assam, and yields a large proportion of the silk which is exported from that district. *Antheræa paphia*, Linn., is the source of the Tusseh silk of Bengal, which is universally used by the natives of India, and large quantities are sent to England. *Antheræa yama-mai* feeds on the oaks of Japan, and is one of the most successful of the species whose introduction into Europe is being attempted.

Amongst the schemes to which we have vaguely referred few are of more importance than Captain Hutton's plan of restoring the larvæ to their original healthy condition; since this plan is a practical application of rules, which, if sound, will be useful in the case of any diseased or degenerated breed of animals or plants. Captain Hutton attributes the debilitated constitution to the effects of a domestication for 4000 years, and to the neglect by breeders to reinvigorate the stock by an occasional introduction of the wild caterpillars. He contends that the paleness of the colour of the domestic silkworm, which is seldom darker than an ashy white, indicates a weakness of constitution, and that the exceptional dark individuals which are seen now and then represent the original colour of the domestic breed, and the true colour, or an approach to it, of the larvæ in their native state. He insists that it is useless to import fresh eggs (or seed as they are usually called) from extra-European countries, since disease is rife in all of them. Impressed with the idea that these dark individuals, the *vers tigrés* of French breeders, possess a stronger constitution than their paler relatives, Captain Hutton attempted to increase their number by rearing a fresh breed from the dark worms only. He reared the dark batches in the same room and under precisely the same circumstances as the light worms; and he soon found that the rate of mortality amongst the former was very much less than amongst the latter. His first set of experiments were brought to an end by the destruction of all his eggs by a violent gale of wind. He renewed his experiments, and with the same favourable results as before. As an evidence of what he effected we will quote his account of the breeds produced in 1863. "In the spring of 1863 the eggs obtained in the previous year from the dark stock began to hatch on the 16th of March, and no sign of disease was apparent among them until the moths came forth from the cocoons, when many of them still showed defect in the malformation and dark spotting of the wings. As compared with the previous year there was decided improvement; there were still too many white worms in the brood, but they did not show any symptoms of disease, and none died; they attained to a larger size by a quarter of an inch, measuring from three to three and a quarter inches in length; they produced in consequence larger cocoons, though still deficient in silk, and the moths, although still showing the presence of disease, laid good-sized eggs, great numbers of which adhered firmly to the paper upon which they were deposited, and indeed one sheet of paper was thickly covered with them, a thing which, although I have paid attention to the subject for the last twenty-five years, I never witnessed before, nor even heard of it. The eggs of other species will adhere, but to find those of *Bombyx mori* doing so is truly a novelty which betokens decided progress towards a healthier condition. There was likewise another indication of returning strength to be seen in the fact that while ordinarily the male moths are so sluggish as to make no attempt to fly, many of those produced from my black stock left the trays and flew off to seek the females in a distant part of the room. This is one of the marked characteristics of the wild moth of *Bombyx Huttoni*, which flies off from tree to tree for long distances when 'on amorous thoughts intent.' But still more extraordinary appears the fact that some of the eggs of *B. mori* of the spring crop of 1863 began to hatch again for a second crop on the 7th of August the same year: these were all from the dark stock, and the circumstance, in itself perfectly novel, arises, I am inclined to think, from an accession acquired by reversion to a state approaching more nearly the original condition. The hatching continued throughout August, and occasionally even to the 28th of September, when fearing that my supply of leaves would fail, the eggs were removed to a temperature below 70° Fahrenheit in order to check the hatching. The worms now hatched continued to grow and thrive, and spun good cocoons superior in size to those of the spring crop, the worms attaining to $3\frac{1}{10}$ inches in length. In due time the moths appeared and were fully twice as large as those of spring, depositing large well-formed eggs. In the beginning of December, to my dismay, more worms were hatched from the spring batch, and continued to come forth throughout the month at the rate of 40 or 50 daily in a temperature of 53° Fahrenheit, when, having no more leaves upon the trees, I was compelled to place the remaining eggs out in the open air at night in order that the sharp hoar frosts might effectually put a stop to any further hatching. All these worms were of the dark kind, and no white ones now appeared among them, as in the spring; indeed from the white stock only three worms were produced, and these came to nothing. This circumstance, so thoroughly unusual with *Bombyx mori*, I attribute entirely to an accession of health and strength in the black worms, which are evidently now in a transition state which may account in some measure for their hatching out of season, so irregularly and in such a low temperature." In 1864 he obtained a still larger proportion of dark worms; but the results were not so favourably progressive as in the preceding year. The disease had had so long a standing that it would require a very long time to regenerate the breed; so that Captain Hutton thinks the best plan would be to breed from the wild worms if procurable. In support of his opinion that the worms were dark coloured before they were domesticated, he appeals to the above experiments, and to the fact that the dark individuals approximate to certain species which occur wild in the district. He also alludes to the general tendency of domesticated species to acquire a lighter tint, either in patches, as in piebald horses, or generally in all parts of the body. The native country of the true *Bombyx mori* is in the north of China, where the climate is very severe in the winter. This species will not thrive in the hot regions of the Punjaub so well as in cooler climates; and the French worms are superior to those of the sunnier clime of Italy. The deterioration of the worm is manifested partly by the prevalence of disease and partly by the diminished weight of the cocoon; but the quality of the silk is little if at all affected.

Captain Hutton points out that several species have been confounded together under the common appellation of *B. mori*. He considers that the genus *Bombyx*, Schranck, may be arranged in two sections; to the first might be assigned the cultivated larvæ which have a pale cream colour, and a single fleshy or semi-corneous spine situated on the dorsal surface of the penultimate segment; and to the second the larvæ of the wild species, which are adorned with bright and variegated colours, such as ashy grey, livid green, yellow, rufous, ferruginous, and black, and have from four to six longitudinal rows of spines with a backward curve, in addition to the one on the penultimate segment. In experimenting upon *B. mori* he found that the reverted specimens approached the second group as regards colouring. He believes the *B. mori* usually referred to by writers embraces most of the following species:—*Bombyx mori*, Linn.; *B. textor*, Hutton; *B. Crœsi*, Hutton; *B. fortunatus*, Hutton; *B. arracanensis*, Hutton; *B. sinensis*, Hutton; *B. Huttoni*, Westwood; *B. bengalensis*, Hutton; *B. subnotata*, Walker; *B. Horsfieldi*, Moore; *B. Sherwilli*, Moore; *B. religiosæ*, Helfer.

The larva of *B. mori* is the largest and strongest of the domesticated species; produces generally but one crop each year; and thrives best in a moderate temperature. The differences between the ordinary cultivated worms and the reverted specimens are described, and we append the author's description. The young caterpillar, as usually reared, is hairy and dark brown on leaving the egg. The edge of the anterior segment is ashy white, while the legs and pro-legs are jet black. During the first four or five days, and previous to the first moult, the five anterior segments gradually alter from brown to brown spotted with livid ash, and finally they are entirely of a livid ash colour. Concomitantly with this change of colour there is a change of form, so that they ultimately present a somewhat swollen appearance. The hairs are arranged in two rows, one on each side. At the first moult all the hairs disappear, the median spine on the penultimate segment, however, still remains. In the second stage the anterior segments become ashy white, and the other segments become spotted or mottled with grey; on the fifth segment are two faint semilunar brown marks, and on the eighth two small brown spots; head and the pro-legs black. After the second moult there is a great increase of the ashy or creamy white tone; and the second and third segments are much more wrinkled than before; on the front of the second segment is a thin longitudinally disposed dark line with generally a small dark spot on each side of it; two dark semilunar marks on the fifth segment; and dark spots on the eighth which are now somewhat raised; the anal spine has passed from a mere tubercle into a slightly curved process; the head is mealy grey-brown, and small as compared with the body. Few changes occur in the subsequent moults beyond increase of size, and a greater conspicuousness of the markings; that on the fifth segment becomes crown shaped, and the spots on the second become uniform. The adult is about three and a quarter inches in length. The dark or reverted specimens are like the pale ones up to the first or second moult; then, however, the caterpillar is of an almost uniform mottled grey colour, with an ashy stripe, "which, crossing in front of the anterior segment, runs round on each side as far back as the middle of the fifth segment, widening up towards the back, but leaving a dark brindled dorsal space between them." In subsequent stages this band becomes less well defined, and approaches a roseate hue. There are two dark lunules on the fifth segment, and sometimes two dark spots on the eighth. In the third and fourth stages the colouring increases in intensity, and becomes like a "trellis work spread over an ashy grey ground." When about to spin, the colours become paler, the ashy grey turning to a sandy brown. The anterior portion of the second segment rises somewhat abruptly, "and from it, through the dorsal centre of the first, runs a narrow black longitudinal line, on each side of which, on the second segment, is a round black spot, perpendicularly divided by a pale orange line, causing the appearance, as it were, of two eyes."

(Captain Hutton, *Transactions of the Entomological Society of London* [3], ii.; F. Moore, *Proceedings of the Zoological Society of London*, 1865.)

BOMBYCILLA. The species of this genus are now generally called by the name *Ampelis*.

The range of *Ampelis garrula* extends all along the northern part of Europe, Asia, and America; a few flocks and individuals occasionally migrate as far south as the latitudes 30° and 40°. Swinhoe records its occasional occurrence in North China, Amoorland, and Japan, showing that its ranges in Asia and Europe nearly correspond. Several facts have been recently recorded, indicating the whereabouts of its breeding places. Thus Ross ('Natural History Review,' 1862, p. 280) mentions the finding of an egg on the banks of the Youcon river, and reports that these birds make their nests in large numbers high up in the trees in the vicinity of the Great Bear River in 65° N. lat. Mr. Wolley has also described the nest of this species as seen by him in Lapland. This shows that it breeds in about the same latitude in Europe as in America. The nest is large and well shaped. It is mainly composed of the hair-like lichens, which grow on the trees, intermingled with a few bits of reindeer lichen, mosses, and grasses. It is generally placed in the branch of a tree in open parts of the forest. The eggs are usually five, but occasionally six, in number; the ground colour is pale, and upon it are distributed several large purple spots. The eggs in the same nest appear to be uniform in size; but those of one nest may be considerably larger than those of another. A young bird is thus described:—It had a general resemblance to the adult, though all the colours were more dull. The wax-like ends to the wing-feathers, the yellow tip to the tail, the black patch between the eye and the beak are all there; whilst the rich mahogany of the under tail coverts is of a quiet brown; the blooming vinous colour of the head and back has not yet emerged from a homely neutral, and the crest is but just indicated by the longest feathers of the crown. The most marked difference between the adult and young is in the throat and under surface generally. There is at present scarcely a trace of the deep black patch of the chin, and the delicate tint of the general under surface of the adult is replaced by mottled neutral and white. This upon examination is found to owe its appearance to those longer webs which, arising towards the root of each feather, extend as far outwards as the webs which arise nearer its tip, being very pale or white, and thus relieving on both sides the last-mentioned darker webs. (Wolley, 'Annals of Natural History,' 2nd Series, vol. 20).

A. phœnicoptera. This bird, which until lately was only known as an inhabitant of Japan, has been found in Siberia. Radde states that it doubtless breeds in the Bureja mountains north of the Amoor, since he saw flocks of lately fledged birds in the woods of that district in August and September.

BOULDER-FORMATION [E. C. vol. i. col. 612; DILUVIAL FORMATION, E. C. vol. ii. col. 343]. The term boulder-formation has had many misconceptions connected with it. By some geologists it has been applied to a series of the more recent superficial strata, and by others to certain beds forming part of the same series. It is now usually employed in its more restricted sense; and is never used to indicate what were formerly embraced in the term diluvial formation. The boulder-formation, or the boulder beds, as we think the strata referred to might more correctly be called, represents a set of phenomena which appear to have been of rare occurrence in past geological times. Almost every bed of the thousands which make up the miles of accumulated deposits known to geologists has been formed in one of four ways. The matter comprising them has been derived from the degradation of land, and been strewed over the bottoms of water-filled hollows by the action of currents; a liquid is the essential transporting agent, and the particles are more or less rounded. In the second way the matter has been precipitated from solution in the waters, which formerly covered the site where the bed is now found, by organic agency. In the third way the matter is deposited from solution in water by direct chemical action, or rather by chemical action without the intervention of organic life. In the fourth way the materials have been ejected from volcanoes in a pulverulent form, and have gradually settled down sometimes on the land and sometimes at the bottom of lakes, seas, &c. All limestones, sandstones, grits, shales, clays, and conglomerates have been formed by one or other of these processes, and the great majority of them by the first-mentioned. In a few instances the beds are composed of fragments which were broken off from rock masses by the action of the weather, and rolled into the nearest depressions. In addition to all these are certain beds, in the aggregate of comparatively insignificant dimensions, which are partially or mainly composed of large masses of rock presenting few or no signs of having been transported far by the action of currents, and yet they have evidently been transported some how or other, since their parent rock is known to exist twenty, thirty, and even hundreds of miles from their present localities. Such beds are, as we have already mentioned, of but rare occurrence; their peculiar feature is that large blocks of angular stone with polished or striated surfaces rest upon, or are embedded in, a fine-grained sedimentary deposit, generally clay or shale. A few cases are recorded from Miocene, Eocene, Cretaceous, Permian, Carboniferous, and Devonian strata ; but the best marked and most numerous are confined to a very recent period, that of the Post-Pliocene. As these are best considered in connection with the other strata of their respective periods, further remarks on the boulder-beds will be given under POST-PLIOCENE, E. C. S., and under the headings MIOCENE, EOCENE, CHALK FORMATION, PERMIAN, and OLD RED SANDSTONE, in this volume ; while the general facts connected with the boulders themselves will appear under BOULDERS, E. C. S. The old palæozoic boulder-beds have not been sufficiently studied to warrant the assertion that they have been formed in the same way and under similar conditions to those of the Post-pliocene period ; at any rate the term boulder-formation is never applied to them. It may be also mentioned that all those huge angular or sub-angular masses which are scattered more or less thickly over the surface of the northern parts of the European, Asiatic, and American continents, without being embedded in a sedimentary deposit, are not comprised in the expression of boulder-formation, although, like the beds which are so called, they belong to the same set of phenomena.

BOULDERS [E. C. vol. i. col. 612 ; ERRATIC BLOCKS, E. C. vol. ii. col. 614 ; GLACIERS, E. C. vol. ii. cols. 1031—1035]. Boulders and erratic blocks are those large angular or subangular rock masses which are in many cases marked with one or more sets of parallel scratches and grooves, and which generally occur under such circumstances that it seems highly improbable that any appeal to violent floods or suddenly upraised mountains will satisfactorily account for all the phenomena connected with them. Cataclysmic deluges might be accepted, if the boulders were simply large rounded stones, such as those near Inverness, which are as well rolled as pebbles, and sometimes from two to four feet in diameter ; but no flood or violent current of water can be supposed to have transported masses many tons in weight for hundreds of miles, and deposited them in a finely comminuted clay on the tops or flanks of hills, or on gravel, with their angles sharp and unworn. Even in those boulders which have travelled a few miles only it is inconceivable that their transportation can have been by local floods ; for this would still leave unexplained the parallelism of the scratches, and the distribution of the blocks in radial lines from a common centre. As has been pointed out under ERRATIC BLOCKS, E. C., boulders occur under a great variety of circumstances, and hence no one mode of distribution is applicable in all cases. The main agent has been the buoyant power of ice, which has been pressed down the channels of the mountain sides, and from the higher parts of a continental area to its lower sea-bounded margins, or drifted along by oceanic, lacustrine, and fluviatile currents. Wood, such as logs, and other substances capable of buoying up heavy weights in water, are accessory and comparatively unimportant agents.

In this article attention will be confined : (1) to the modes of occurrence of boulders ; and (2) to illustrations of the power of ice in effecting the production of the parallel scratches, and in transporting the blocks. While under POST-PLIOCENE, E. C. S., an attempt will be made to show how the greater prevalence of continental and valley glaciers in lower latitudes than at the present day, the northern or rather arctic character of the fauna of the period, and other evidences of intense cold in all the localities where boulders are now found, harmonise with and lend support to the view that ice was the great transporting agent during this period in the polar halves of both hemispheres.

In the first mode of occurrence to which we propose to draw attention, the boulders are for the most part situated on the summits and flanks of the higher elevations of the district, and are generally embedded or promiscuously arranged in a hard tenacious clay which is commonly found resting immediately upon hard rocks. The boulders are derived from rocks developed in the district at distances ranging from 10 or 20 up to, in certain rare instances, 300 or 400 miles. Their situation is such as to show that the transporting agent has been uninfluenced by the minor inequalities of the ground, since valleys and ridges of considerable size intervene between their present position and the rock mass from which they were derived. Sometimes, even, it happens that the parent rock is situated at a lower level than the boulder itself. In some districts the course of this class of boulders has been southerly and northerly, with variations towards the east and west from the principal watershed ; while in others they have diverged in opposite directions from two or more of the principal watersheds of the country. Illustrations of most of these statements are to be seen in the British islands, but the most striking examples occur on the European and American continents. In this country the phenomena are best shown in Scotland, where they have been carefully examined by Jameson and others. From these researches we learn that the rocky surfaces of the country as well as the boulders are ice-worn, and covered with parallel striæ. The striæ on the boulders frequently coincide in direction with those on the subjacent rock, and this direction also coincides with that in which the parent rock of the boulders lie. "Thus," says Professor Jameson, "on the top of the sandstone hills that form the south end of the island of Bute, we find the ice-worn *débris* of the mountains of Argyleshire ; in the boulders of Inverness we find samples of rocks that occur along the line of the Caledonian Canal ; and at Aberdeen we get specimens of all those that are to be met with in the valley of the Dee." The character of the mud in which they are embedded frequently affords a good indication as to the direction which the movement has taken. This is well seen in the country to the south and south-east of the central highlands of Scotland. An observer passing from Ben Nevis to Edinburgh would notice that the rocks in the more northern and mountainous districts are chiefly granites and mica schists, in which the general tone of colour is grey. Then would follow a broad zone of more level country characterised by a red sandstone, which is succeeded on the south by the coal measures. The prevailing colour of the boulder mud follows the order indicated by these rocks. Thus, in the north of the area under consideration it is of a dull greyish tint ; further south it is reddish ; further south it is brown ; and beyond this it becomes blackish. On comparing the boundaries of the colours in the boulder mud and in the parent rocks it will be observed that the former overlap, or extend southwardly of the latter. Thus the greyish tint of the boulder mud of the grey granite and mica schist area does not lose its greyness until several miles of the red sandstone have been passed over. Again, on passing from the red sandstone to the coal measures the redness of the boulder mud shades off from bright red through dull red and various tints of brown to black. The fact that the underlying rock imparts its colour to the boulder mud for some distance beyond its southern border not only indicates the direction in which the mud has been moved, but it also shows that the transporting agent powerfully degraded the area over which it passed. The degradation occurred over a continuous breadth of many miles, and not along a number of narrow channels. The distribution of the boulders derived from this same area does not indicate so regular an arrangement in zones, but their lithological character, together with the circumstances already referred to, leave little doubt as to the direction in which they have travelled. Thus on the shores of the Forth the boulders represent all the harder rocks between that river and the Grampian Hills. We may find there granite and mica schist from the Grampians, old red sandstone from the Lowlands, volcanic rocks from the Ochils, and fragments from the coal beds of the immediate district. Granite boulders have also been carried north-westwardly in large numbers from the Ben Mac Dhui range across the valley of the Spey and far up the flanks of the hills near Aviemore. The rocks and boulders of Arran show the same phenomena on a smaller scale. The northern and higher parts of that island are composed mainly of two varieties of granite—one coarse-grained, and the other fine-grained. The Goatfell group of mountains consists entirely of the coarse-grained granite; while the sides of Glen Iorsa, together with the eminences situated towards the western side of the island consist, partly of the fine-grained, and partly of the coarse-grained. The large proportion of the boulders of Arran are derived from these rocks, and are massed together in the more southern parts of the island. Their position shows clearly that they have traversed the island from north to south, and occupy the same relative positions as their parent rocks, those from Goatfell being grouped together to the east of those from Glen Iorsa. It is also noticeable that the Arran boulders are exclusively derived from Arran rocks, there being few or none from the adjoining mainland; and that, to use the words of Dr. Bryce, "they have passed down slopes, across glens, up steep inclines, again and again, to reach the points where they are now lodged." Much of the boulder-containing drift of the north of England, especially that about the head waters of the Tyne, Wear, and Tees, appears to have been transported in the same way as the Scotch boulder clay. In America, also, there are abundant examples of this mode of occurrence. In Massachusetts and Vermont, for instance, there are long trains of boulders whose sources lie at distances varying from 20 to 100 miles in a northerly direction, and their line of movement is quite independent of the valley structure of the district. Thus on Hoosac mountain there is a granite boulder believed to have been transported across the adjoining valley, the depth of which is 1500 feet; while the iron ore beds at Cumberland, New England, are represented by boulders stretching 35 miles to the south. The country on the south side of Lake Superior is bestrewn with boulders derived from its northern shores. Numerous other examples are mentioned under Erratic Blocks, E. C.

In the second mode of occurrence there is an absence of the tough clay, and if any clay is present its texture is more loose and open. The boulders, mostly from local rocks, are distributed along the principal river valleys, and are more abundant in the upper than in the lower portions. They frequently occur in the large ridges or mounds which extend partially or across certain portions of these valleys. In many instances boulders of similar material occur in long trains, side by side with trains of boulders formed of other materials. Indeed, it may often be noticed in this class of boulders that not only have they not crossed valleys and ridges, but they have not even crossed from one side to the other of the same valley. This is exemplified by the Wye valley, where boulders of millstone grit and limestone are abundant on the one side, but absent on the other. The boulders at Detmold, in the valleys of the Limmat, the Rhine, the Reuss, and the Aar, referred to under Erratic Blocks, E. C., are also examples of this class; and hundreds of others might be cited in the northern parts of Europe, Asia, and America, as well as in New Zealand. In the third mode of occurrence the boulders are sometimes isolated, and sometimes in patches. They are generally composed of rocks situated at great distances, and the patches are generally heterogeneous in composition as well as promiscuous in arrangement; and they are situated on the tops of the lower hills, along the sides and bottoms of valleys, and on plains, but their situation has no evident connection with the present river systems. Examples of this kind are afforded by the boulders of Westphalia, Lithuania, and Potosi, mentioned under Erratic Blocks, E. C. The few boulders found in Devonshire and Cornwall also appear to be examples of this class.

There are yet two other recognisable modes of occurrence, but it is frequently difficult to distinguish one from the other, or either of them from those which have been already described. In both the boulders are frequently of local origin; but they do not possess the orderly arrangement and that restriction to river valleys immediately connected with the parent rocks so characteristic of boulders of the second mode of occurrence; and if they are associated with tough clays, they may generally be distinguished from those boulders which occur in the first mode mentioned, by such clays containing marine shells, mostly in a more or less comminuted condition.

The examples which we would, with hesitation however, assign to the fourth mode of occurrence, are the granite blocks from Wasdale Craigs, the boulders scattered over the low lands of Livonia, and those which occur in the glacial drift of Caithness. The distribution of the Wasdale Craig boulders has been ably sketched by Professor Phillips ('British Association Report for 1864,' Notices, p. 65), whose account we take, since we are unable to describe it ourselves in better words or in shorter compass. The blocks occur plentifully in the drainage of the Eden, the large tracts embraced by the northern and eastern branches of the Humber, and the long depression on the western side of the carboniferous chain of Yorkshire and Lancashire, but are quite unknown in the country to the westward of the parent rock. In following the course of the blocks from the extreme south-east of Yorkshire, it is found that they do not follow the valleys and avoid the heights, but, on the contrary, with little or no difference they occur alike on hills and dales, though not on the very highest, till on Stainmoor they appear on surfaces raised 1400 feet above the sea. Through this pass of Stainmoor, which, though so much elevated, is in fact a great transverse depression in the carboniferous chain, the blocks have passed on as through the strait of an ancient sea. At no other point have the blocks passed the chain. In the country to the west of Stainmoor the blocks are frequent at all elevations below about 1000 feet above the sea; and on approaching Wasdale Craig they become so numerous as to be counted by hundreds and thousands. As Wasdale Craig itself is only 1479 feet high, the distribution has clearly not been due either to glaciers or to floatations by icebergs, unless great alterations are assumed in the relative levels of different tracts of the land, as well as of the land to the sea. Wasdale Craig itself is in the drainage of the Lune. To the north and west of it the summit of drainage between the Eden and the Lune is traced over varying heights greater and less than that of the Craig. This drainage summit is passed by the blocks at a level below 1000 feet, a little to the north of east from the Craig. South-west of the Craig is the watershed between the Lune and the Kent. This summit appears not to have been passed at all, though in many places it is much below the height of the Craig. The blocks are often of very large size; some within two or three miles of the Craig are twelve, fourteen, eighteen, or even more feet in the greatest diameter, and at Thirsk, 70 miles off, is a block thirteen feet across. They seldom appear to have been rolled, but yet, perhaps by ordinary surface waste, they have often become blunted at the angles. Our own suggestions as to the way in which the distributions appear to have been brought about will be given presently, but we will append here the conclusions to which the Professor himself has been led. He states his conviction —(1) that the distribution is best explained by the agency of ice; (2) but not by glacier action on the land at its present absolute elevation; (3) that iceberg floatation cannot have done it if the present relative elevations were the same then as now; (4) that the excessive abundance of blocks near the Craig seem to require the supposition of a considerable disturbing force which greatly shattered the Craig. It is thought that during the glacial period such a disturbance took place; that the lake district was depressed; that icebergs, formed from shore ice and at moderate depths in the sea, carried away many of the loosened blocks over the region far away in the east, when relatively lower than at present; and that they were distributed while the land was rising. The Professor has here confined his remarks to Wasdale Craig, but the harder rocks of Shap Fell and other eminences of the Cumberland range have supplied boulders which have taken the same direction as those from Wasdale Craig. We will next turn our attention to the boulders of Caithness. The north-eastern part of this county is a low undulating plain, which has a general slope towards the north-east. It is bounded on the south-west by lines of rocky cliff cut out of the hills which form part of the mountainous region of Sutherlandshire. The depressions in the more level part of the county are filled with a pebbly silt and clay up to from 100 to 150 feet above the level of the sea. The deposit is for the most part without any signs of stratification; small fragments of shells are scattered in considerable abundance throughout the greater thickness of it; and the lower portion, of a greyish tint, is generally firm and solid, as though it had been strongly compressed. In this last character it has considerable resemblance to the boulder clay of the west coast and the southern half of the east coast of Scotland; and hence it has frequently been spoken of as true boulder clay. It passes upwards into a more open clay of a reddish-brown colour, and full of striated ice-worn stones and boulders. The boulders consist of sandstone, mica schist, and granite, such as are to be found in the county itself. The rock upon which this deposit rests is marked with striæ, the great majority of which have bearings ranging from N. 30° W. to N. 60° W., allowance being made for the present variation of the compass. As the direction of movement of the clay has a close bearing upon the question as to how the boulders were transported, we cite the following passage from a paper by Professor Jameson ('Quarterly Journal of the Geological Society,' xxii. p. 268): "The impression left upon me by all I saw was, that the movement had been from north-west to south-east; for where I observed any indication of a *stosseite* it was on the north-west side. In order to obtain further evidence on this point I endeavoured to trace the boundary of the dark grey drift, for I thought that, had the movement come from the north-west, the dark grey mud derived from the Caithness flags should overlap the red grit and conglomerate towards Dunbeath and Berriedale, while the flags themselves should be overlapped at their north-western boundary, towards Reay, by a differently coloured drift. This I found to be the case. The dark grey mud fills the bed of the Forss water, but does not extend beyond the watershed between that stream and the Burn of Isauld; and at Reay the drift covering the flags is of a reddish-brown colour. On the other hand, the dark grey mud stretches south-eastward, past Lybster, into the bed of the water of Dunbeath, and lies in heavy masses even in the south branch of that stream. I also traced it to the mouth of the Berriedale water, where it mingles with the reddish-brown drift that prevails from there to the Ord; but further up the Berriedale glen, to the base of the Scarabin hills, the colour is reddish brown. The distribution of the dark grey mud therefore harmonizes with the supposition that the transport had been from the north-west; and a movement of ice from north-west to south-east across Caithness is totally at variance with the notion of the scratches having been caused by glacier action proceeding from the interior of the country towards the present coast. I have already mentioned that the stones imbedded in the drift of Caithness very often show the glacial striæ. When examining the sections along the Haster Burn, in company with Mr. Joseph Anderson, I remarked that the striæ on the imbedded fragments generally agreed in direction with those on the rock beneath. The scratches on the boulders, as usual, run lengthways along the stones when they are of an elongated form; and the position of these stones as they lie imbedded in the drift is, as a rule, such that their longer axes point in the same direction as do the scratches on the solid rock beneath, showing that the same agency that scored the rocks, also ground and pushed along the drift. Interspersed among these ice-worn stones were many fragments of shells—themselves also scratched—and some univalves almost entire." These fine parallel scratches occur on fragments of the most fragile shells, and even on *Foraminifera*. Although almost undistinguishable in physical structure from the boulder clay of Perthshire and Stirling, the drift of Caithness differs from it in several important points. It is fossiliferous; its direction of movement points not to a high watershed, but to a wide expanse of ocean; it is far more recent than the true boulder clay; and the area over which it extends is believed to be entirely free from old glacier moraines. The question of age is an important one in connection with boulders, but it cannot be dwelt upon here; details upon this point will, however, be found under Post-Pliocene, E. C. S. Lastly, we would refer to the boulders of Livonia, which are distributed over a plain which is at present but little elevated above the sea. The peculiar feature about them is, that while their positions seem to indicate that they were distributed over the bottom of a sea, yet the gravels and sands connected with them are unfossiliferous and non-marine in character, and the underlying surfaces are marked with parallel scratches. Their mode of occurrence is difficult to account for on the supposition that they have been brought either by icebergs or glaciers; and a different mode of accounting for them will be noticed when we refer to the transporting powers of different forms of ice.

The peculiarities of the fifth mode of occurrence will be gathered from a few examples. A little below Bridgnorth two well-marked terraces are seen in the valley of the Severn, one at 113 feet and the other at 156 feet above the level of the sea. Along the crest of the upper terrace there is a pebble ridge composed of rounded boulders mixed with a little gravel. Some of these boulders are of considerable size, and their composition is as various as the strata occurring in the higher part of the valley of the Severn. They are subangular, free from well-marked glacial striæ, more or less abundant all up the valley to Shrewsbury, and generally most abundant in the higher grounds ranging from 400 to 800 feet above the sea. Mr. Maw states that their local distribution is remarkable, the ground in some places being thickly strewn with them, while at others, where it is equally elevated, the boulders are almost entirely absent; and he suggests that their partial distribution may be accounted for by supposing that they were not merely casually dropped from floating icebergs, but deposited wherever they happened to ground. Otherwise, he remarks, the tendency would be for the low ground, which was longer under water than the higher hills, to receive a larger instead of a smaller proportion of them. We believe, however, icebergs had nothing to do with their distribution. Along many of the river valleys of the southern counties of England, gravel beds are frequently found at moderate heights above the present stream, generally between 20 and 50 feet. In these gravels numerous blocks have been observed, generally of sandstone, and sometimes of considerable size. Thus Mr. Evans refers to several derived from the gravel near Hillhead in Hampshire, one of which was 2 feet 6 inches thick, and 22 feet in circumference. Mr. Coddington refers to some in the gravel near Thame, and many others have been recorded by other observers. They are frequently associated with fresh unrolled chalk flints. It is, however, not unlikely that some of the masses of sandstone found in drifts and gravel beds have been consolidated *in situ*. In such cases the presence of angular flints, the want of conformity between the bedding of the block and the stratification of the gravel, the irregular disposition of the blocks and a marked inequality between the grains forming the sandstone, and those forming the immediately surrounding sand or gravel, are the principal circumstances which indicate that it is a transported boulder. These gravels, we would mention, are in all probability of fluviatile origin. Above the boulder clay of the southern friths of Scotland is a laminated marine fossiliferous clay, in which have been found a few boulders. They are generally fragments, 6 feet or so in length, of crystalline rocks, and in most cases they are marked with glacial striæ. Not unfrequently colonies of *Balani* occur on both their upper and lower surfaces. Professor Jameson has some interesting observations on this point. "Now," he remarks, "it is quite common in some of the pits [near Paisley] to find a crust of *Balani* attached to one of these boulders, and I think it has generally been supposed that the *Balani* are confined to the upper surface and sides of the stone, as if they had grown upon it after it had been dropped into its present position. I satisfied myself, however, that this is not always the case, for I found that *Balani* do occasionally occur all over the lowermost side. For example, I observed one heavy stone, measuring 32 inches in length (32 × 14 × 18 inches), imbedded in the clay about 15 feet from the surface. This boulder had not been moved out of its original position, and there were remains of *Balani* on various parts of the surface. With the assistance of the foreman of the work I dug round it, and heaved it out of its bed, and found that the whole under side of it was covered with a close thick crust of entire *Balani*, the points of which were sticking downwards into the soft clay beneath, showing clearly that they must have grown upon the stone before it was dropped into its muddy bed. Other instances of the same kind were observed by me in this brick work. I conclude, therefore, with regard to these boulders at least, that *Balani* grew on them before they came to be lodged in the clay (probably when they lay on some shore), and that afterwards they had got encrusted with ice, and being floated off had dropped to the bottom when the ice about them melted. I noticed that these boulders, with the *Balani* on them, sometimes exhibit glacial scratches. Here, then, we have evidence of three distinct events; first, the boulder was scratched; secondly, barnacles grew upon it; thirdly, it was carried off and dropped to the bottom of the sea. If this transportation was due to floating ice (and I do not see to what else we can ascribe it), it would therefore appear that the floating ice had nothing to do with the scratching of the stone." Many of the boulders collected round the margin of old lacustrine areas are examples of this fifth mode of occurrence. Thus in the Himalayas there are extensive plains which were formerly the sites of large lakes, and the valley of Skardo is one of them. Captain Godwin Austen describes it as a plain surrounded by high mountains. In the centre of this plain rises the Rock of Skardo to a height of 800 feet. On the summit of this rock and along the mountain slopes, at elevations overtopping the rock, are vast accumulations of angular detritus, conglomerates, and boulders. These accumulations mark the former level of the lake. The great plain of Hungary and the Danubian principalities seems to have been at one time the site of a great lake or inland sea. Round the margin of this basin we find here and there deposits of gravel characterised by boulders of trachyte, basalt, and rhyolitic rocks. These boulders appear to be free from glacial striæ, although they are more or less angular.

Having thus grouped together and classified the principal circumstances under which boulders are found, we will indicate either in this or in other articles to be referred to, in what way the ice is supposed to have acted in each of the five groups. Before doing so, however, we would say a few words respecting the arrangement of the foregoing part of this article. If the reader will consult Post Pliocene, E. C. S., he will find facts stated which seem to lead to the conclusion that Scotland and probably other northern countries have passed through similar conditions which have succeeded each other in the same general order. Stated shortly, those conditions were the envelopment of the whole of the land in a thick covering of snow and ice; the subsidence of a large proportion of the land accompanied by the dissolution of the ice cap; the re-elevation of the land, and a re-accumulation of ice and snow, but not to so great an extent as before the period of submergence; and subsequent to all these a second depression, during which a gradual amelioration of climate occurred, and the valley glaciers disappeared. During each of these phases the action of the ice was different, so that the principal effects produced by it during each period are recognisable by well marked characteristics. It is probable that most of the boulders which we have cited as examples of the same mode of occurrence were transported when the condition of the country as regards glaciation was in the same phase. The order of the modes of occurrence corresponds with that of the phases; and hence it is probable that the arrangement followed is roughly chronological.

The boulders of the first group were, we conceive, transported by the outward movement of vast continental glaciers which covered the northern parts of America, Europe and Asia, during what is called by geologists the glacial epoch. Those of the second group were brought down from the high lands by glaciers descending through valleys. The carrying powers of valley glaciers have already been described under Glaciers, E. C.; while those of continental glaciers will be referred to more particularly under Glaciers, E. C. S. The transportation of the boulders of the third group appear to be best explained by icebergs, which are known to be charged with great loads of earth and boulders, and which would discharge their burdens so as to produce patches resembling those we have described. Scoresby saw several which he estimated had from 50,000 to 100,000 tons of earth and stones.

The boulders of the fourth group appear to have been moved by what are called ice-fields, more especially when forced against shores or through narrow straits during storms or by strong oceanic currents. These ice-fields are great masses of ice from 30 or 40 up to 400 feet in thickness, and many miles in extent. They originate only partially from the waters of the ocean. Sea-water is never frozen by the simple action of intense cold to a greater depth than 18 feet. When an intense frost sets in in the Arctic regions a thin sheet of ice forms over the surface; this soon gets broken up by a storm, and the masses floating about gradually thicken, partly by solidifying the moisture which condenses upon them, and partly by the additions received on their surfaces during snow storms. These masses are drifted by currents into narrow straits and sounds, and are so hustled and jammed together that their edges rise up into hummocks and ridges from 10 to 100 feet high. When the Arctic winter sets in these masses are imbedded in a sheet of ice, and are so closely packed that enormous pressure is exerted upon the sides of the straits. Along the shores of Smith's Sound, between Greenland and Grinnell Land, the rocks on the shore are thoroughly smoothed and polished. In addition to these there is another kind of ice which acts in much the same way as the ice-fields as a geological agent, and characterises the same high latitudes. The navigators in the Polar Seas call it the ice-foot or ice-belt. This is a band of ice, of greater or less width according to the inclination of the shore, being widest where the slope is gentlest. It forms along the margin of the sea, extends some way inland, or as far as the bounding cliffs, and is firmly fastened to the shore. In the lower latitudes, where this belt occurs it is formed every winter and disappears during the summer, but in higher latitudes it is permanent, or only dislodged during unusually heavy gales. During the winter, masses of rock are hurled upon the surface of the ice-belt, and sometimes accumulate in enormous quantities. Dr. Kane describes one a little north of 78° N. lat., which clung to the base of the cliffs overhanging the sea. Its surface was covered with huge angular blocks, some of them many tons in weight. The height of the talus of debris, from the surface of the ice-belt to where it met the cliffs, was 590 feet. In this latitude the ice-belt so firmly adheres to the shore that it generally resists the action of the tides. Sometimes, however, the displacement is so great that the entire mass is floated away, carrying with it the fragments which had been luted to its under surface as well as those which had accumulated from above. The violence with which the liberation is effected is described by Arctic voyagers as terrific; great cracks run across the ice with deafening reports, and the rocks are subjected to such strains and wrenches that few vessels would stand it if they happened to be in the line of disruption. The phenomena presented by the distribution of the boulders from Cumberland over Yorkshire appear to have been effected by the packing of the ice tables in the broad depression traversing Cumberland and Westmoreland, the formation of ice-belts round the crags of the lake district, and the discharge of the rock-laden masses through the Gap of Stainmoor. This hypothesis would not require the unequal elevation and depression of the lake district as advocated by Professor Phillips. The phenomena in Caithness seem to be due to the forcing of ice tables and dislodged ice-foots over the area of Caithness, which was probably then the bottom of a shallow sea. The boulders of Livonia appear to have been distributed by a similar agency, that is, the forcing of rock-laden tables of ice over a low lying land; an explanation which has been recently suggested by Count Keyserling. The following digest of his opinions is from the late Mr. Hamilton's anniversary address to the Geological Society in 1866:—

During the first frosts of 1863 Count Keyserling observed that a vast field of ice from 2 to 2½ feet thick had formed itself on the shore of the Gulf of Pernan, extending far out to sea. The water then rose to about four feet, owing to the milder weather, covering the field of ice. This was subsequently raised by the water, and formed a free floating field of ice of enormous extent. A violent storm on the 15th and 16th of January drove this field of ice against the shore, and forced it with great power over the land. Similar occurrences, but on a much smaller scale, had taken place; but now, owing to the much greater thickness of the ice, the event assumed an intensity which had not been observed for several generations; three peasants' dwellings on the promontory of the Tackerort were so suddenly invaded by the ice and destroyed, that the inhabitants lost all their property, and had only time to escape with their lives. The ice here rose 60 feet above the level of the sea; in other places, where the shore was less steep and only 12 feet above the sea, the ice came upon a fir-wood, broke the stems (some of which were 13 inches in diameter), threw them down, and covered them with an unbroken coat of ice. Wherever the floating field of ice encountered a steep precipice it rose up like a sheet of paper, its free edge rose over the land, and then, turning over, fell partly into the sea and partly in fragments over the land, and was pushed further in. On the flat shores of Heuschläger the ice was driven 1023 feet inland, carrying with it a vast quantity of stones; at the same time stones were everywhere raised out of the sea by the ice, and driven on shore. When Count Keyserling himself visited the spot he found a block of granite, weighing about 2160 pounds, lying amongst the blocks of ice, 30 feet above the level of the sea, and which had evidently been raised by the ice from the bottom of the sea, thus confirming the generally received opinions respecting the transport of the stones by means of ice. In another spot where there is a land cliff 30 feet high he found a heap of ice blocks 10 feet thick, which had been generally tilted into an almost vertical position. Their upper surfaces were covered with gravel and stones; the lower surface was pure ice, and had originally formed the upper surface of the field, thus showing that the broken masses of ice had been completely overturned by violent pressure. "If now," adds Count Keyserling, "we could suppose that during the period of the great erratic phenomena the same circumstance took place, but on a larger scale, so that fields of ice of many hundred square miles and four feet thick were periodically driven over the land, we should have a natural explanation of the scratched surfaces in parallel lines, and also of the non-marine character of the erratic deposits." He considers that these phenomena show how blocks of stone out of the sea can be pushed by ice into places far beyond the reach of the water, and how deposits may be formed along the coasts high above the level of the sea resembling true inundations on the shore. Professor Baer also alludes to huge boulders along the coast of Finland, which the inhabitants assert were brought there by great fields of ice pushed over the shore. The island of Laven Lari, on the coast of Esthonia, is even now undergoing such rapid change from the accumulation of gravel and boulders brought by fields of ice, that its present form and outline is widely different from what it was 25 or 30 years ago. And it is highly probable that changes of a similar character have been effected even more rapidly along the northern seaboard of Europe during the long glacial winter which has now retreated farther north.

The examples given of the boulders of the fifth group are arranged in a threefold division according as they were collected along the shores of a river, a lake, or a sea. In the former two cases they were left at the margin of the water, but in the last they were generally arranged in lines at some distance below the level of the water. The agents in all cases are believed to have been river and shore-ice, or perhaps in some cases, ground-ice. The effects are produced where the cold of winter is not very intense, and may be readily seen even at the present time in the rivers and along the shores of Scotland and England. They were, however, formerly much more energetic than they are now in the countries named; and are greater in the corresponding latitudes of eastern Europe and North America. If the ice covering the British rivers during winter be examined various extraneous articles will be seen in it, such as plants, small pebbles, and even fresh-water shells with both valves entire, which objects indicate that some of the ice was formed at the bottom of the river, and, on becoming sufficiently bulky, had floated the weeds, pebbles, &c., to the surface. On the break up of the ice these would be floated away and deposited somewhere else. On the Niemen and other northern rivers which are exposed to more intense and more prolonged periods of cold, blocks of stone three or four feet in length are buoyed up in this way, floated off in the spring, and accumulated along the shores of the estuaries. In Canada the same effects are produced on a still larger scale. In the St. Lawrence the lower part of the river remains frozen over when thaws occur in its upper part. The drifted fragments are packed together by the current, the slabs are piled over one another to considerable heights, and the whole mass is pushed onwards by the dammed-up waters. The pressure thus produced is sufficient to carry along boulders, to break off the projecting corners of cliffs, and even to throw down buttresses of solid masonry. Lyell, in his 'Elements,' states that the buttresses supporting a bridge over the St. Maurice, a tributary of the St. Lawrence, were thrown down in this way and carried into the main river; that wharfs and stone buildings from 30 to 50 feet square, have been removed in the same way at Montreal; and that the strongest cables snap when the ice presses on a brig when riding at anchor. He also figures a scene on the shores of the St. Lawrence, in which large boulders are strewn along the shores in a way which strongly reminds one of the boulders along the valley of the Severn. The action of the shore-ice in lakes is to strand the boulders along the margin, and this is the way we think the removal and arrangement of the boulders of the Lake of Skardo, and of the great plain of Hungary, may be best explained. Sir C. Lyell also describes the action of the shore-ice of seas. The coast of Labrador is lined for 700 miles with ice-borne boulders, many of them 6 feet in diameter, and nearly all of which have travelled from the north, that is, with the prevailing current. The boulders are constantly shifting, so that the spot which is thickly strewed with them one season may be almost free from them the next. The isolated boulders in the laminated clay of Scotland and in the fluviatile drifts of the South of England we would attribute to the floatation of blocks by ground-ice, and their deposition at random over the bed of the sea, and along the margin of the rivers. It is probable that many of the patches of drift derived from local rocks, whose transportation many writers assign to icebergs, have really been placed in their present position by the action of currents on shore ice The following are two examples of this kind out of many which might be cited. The Rev. P. B. Brodie ('Brit. Ass. Rep.' for 1865 (Notices), p. 49), refers to a patch of drift on the high table land from 6 to 12 miles N.N.W. and W. of Warwick, which consists chiefly of sandstone and quartz pebbles, intermingled with fragments of chalk, greensand, oolite, lias, magnesian and mountain limestone, and more rarely granite. Mr. Startin, in the same volume (p. 75), notices several patches near Coventry, more particularly that which runs through the parish of Exhall. The drift to the east of Exhall is derived from the lias, oolite, and chalk; that at Corley and to the west, is composed of rounded quartzose pebbles and small gravel, such as might have been derived from a small area of Bunter conglomerate a few miles to the north; while that at Exhall is almost entirely composed of angular fragments and large boulders from the millstone grit and coal measures which outcrop a few miles to the north. The explanation offered by Mr. Startin, in the case of the Exhall drift, will, we believe, apply to all these cases, including that noticed by the Rev. P. B. Brodie. He attributes it to shore-ice. The Exhall drift, he thinks, was probably deposited when the Warwickshire coal field was an island in a shallow sea. The contour of the coast-line at the time, which was that of the millstone grit escarpment, would account for the drift being found in this position.

The length to which this article has already extended precludes any detailed remarks upon other subjects connected with boulders. Nothing has been said as to the other ways in which blocks may have been transported without being rounded, such as by masses of floating sea-weed, logs of wood, storm waves, &c.; nor has anything been said about the boulders of other than postpliocene times. Thus striated boulders have been found in the miocene strata of the Hill of Superga, near Turin [Miocene, E. C. S.]; others, sometimes with and sometimes without faint indications of striæ, are recorded from eocene beds in Switzerland [Eocene, E. C. S.]; from the chalk of the South of England [Chalk Formation, E. C. S.]; from the Permian beds of Wales and Worcestershire [Permian, E. C. S.]; from the carboniferous formation of Cuttack, in India [Carboniferous Formation, E. C. S.]; and from the Devonian or Old Red Sandstone of the North of England [Old Red Sandstone, E. C. S.]. The evidence respecting these is more or less conflicting and uncertain, and it is seldom that any decided opinion can be offered as to where they have come from and how they were transported. What little we have to say about them will be found under the headings indicated above.

(Godwin-Austen, *Quarterly Journal of the Geological Society*, xx., p. 384; Jameson, *Q. J. Geol. Soc.*, xxi. p. 161; Bryce, *Q. J. Geol. Soc.*, xxi., p. 204; Dana, *Manual of Geology*, 2nd Ed.; Lyell, *Principles of Geology*, 10th Ed.; Hayes, *Open Polar Sea*, 1867; Kane, *Arctic Explorations*, 1856.)

BRACHIOPODA [E. C. vol. i. cols. 643—651], a class of mollusca, about which much has been written of late years, but of the general plan of structure of which it would be difficult to give a clear idea in words only, in consequence of the misconception caused by the acceptance of mistaken views, and the propagation of those views by the continued use of terms suggested in accordance with them. Thus the name given to this class means the "arm-footed," and was proposed because it was imagined that in brachiopods there was a portion of the organism which was homologous with the part called foot in the other molluscan classes. It was imagined that the same portion of the organism was modified for the purposes of creeping, as in the common snail; for leaping or spinning a byssus, as in some of the lamellibranchiates; and for prehensile purposes, as in the brachiopods. This idea has been partially corrected in the E. C. article, but, as we shall endeavour to indicate, the so-called feet of the brachiopods have no homologous relation with the parts so named in other mollusca, and that they ought not to be termed arms. Another source of confusion has arisen from too exclusive an attention having been given to the shell, and a consequent overlooking of the importance which ought to be given to facts derived from the soft parts. The cause of this has, in great measure, arisen from the facility with which shells can be obtained and examined as compared with the living beings which they protect. But the history of the biological sciences affords many a lesson which should teach the student how liable he is to form wrong conclusions so long as he is unacquainted with the whole life-history of a being, or group of beings, and so long as his information mainly relates to a few organs only, or to mature individuals.

A brachiopod is a mollusk with a bivalve shell, in which respect it resembles the lamellibranchiates. Its principal organs are arranged in essentially the same way as in the lamellibranchiates; and the differences which do exist are so striking that the tendency appears to be to overrate their importance. In the lamellibranchiate (of which an oyster may be considered a good example) as in the brachiopod, the organs are symmetrically arranged on a bilateral plan. In an oyster the mouth, the foot, and the anus are situated in the median plane; the nervous system presents three ganglionic masses, one surrounding the œsophagus from which originate the nerves to the labial velæ; the second is near the foot; and the third is below the foot and anus. In the brachiopod there is a nervous centre surrounding the œsophagus, from which originate the nerves supplying the so-called arms, mantle, and viscera; while the pedal ganglia are absent. Judging from the disposition of the nerves it would seem that the labial velæ and mantle of the lamellibranchiate correspond with the mantle and arms of the brachiopod; and that the arms of the brachiopod are, like the labial velæ of the lamellibranchiate, situated right and left of the mouth. The heart is dorsal in both groups. The two lobes of the mantle are, however, differently arranged, and as this is the organ by which the shell is secreted, it involves an important difference in the arrangement of the hard parts, and of the muscles by which the hard parts are connected. In the lamellibranchiates they are situated right and left, and consequently the two shell valves are also right and left; in the brachiopod the mantle lobes are dorsal and ventral, which involves a similar disposition of the valves. So that, while the digestive system has a similar arrangement in both groups, there is a difference with respect to the arrangement of the mantle and shell. And since more attention was given to the shell than to the animal, naturalists long misunderstood the true disposition of the shell in the brachiopod. It was supposed that the valves of the brachiopodous shell occupied the same position relatively to the animal as those of the lamellibranchiate shell; but it is now known that such is not the case. If the position of the mouth be regarded as indicating the anterior end, the opposite extremity the posterior end; and if we call the parts on either side of the line joining these two ends, in the horizontal plane, right and left; and the parts on either side of the same line, in the vertical direction, ventral and dorsal; comparable descriptions of bivalves may be drawn up. The hinge in the brachiopod is posterior, whereas in the lamellibranchiate it is dorsal; the smaller valve of the brachiopod is dorsal; and hence the hinge of the lamellibranchiate has the same relative position as the small valve of the brachiopod. The ventral surface in the brachiopod is formed by the large valve, and by the gape of the shell in the lamellibranchiate. The anterior end answers to the gape of the shell in the brachiopod, and to the shorter expansion of the valve relatively to the umbo in the lamellibranch; the posterior end answers to the hinge in the brachiopod, and the larger expansion of the valve in the lamellibranchiate. If, now, the length of a shell be uniformly accepted as the distance from the anterior to the posterior margin; the width the distance between the right and left sides; and the depth or height the interval between the dorsal and ventral borders; the difference in the arrangement of the shells in the two groups will be seen. The length of a lamellibranchiate generally coincides with the long axis of the shell, as in a mussel; and the height to the short axis at right angles to it, or from the umbo to the widest part of the gape of the shell. The length of a brachiopod, on the other hand, corresponds with what is usually the long axis of the shell, and is measured from the hinge or umbo to the widest part of the gape; while the height corresponds to the short axis, or the line joining the outer surfaces of the two valves. Comparing the brachiopods, as a group, with the lamellibranchiates, it will be observed that in the former the length is the largest dimension in some, such as *Lingula*, and the width in others, as in many species of *Spirifera*; while in the latter the mussel and solens are examples of long species; but there are few, if any, in which the width is greater than any other dimension. In the brachiopods the height is always the smallest dimension, whereas it is generally considerable in the lamellibranchiates, and not unfrequently even the largest dimension. On the average, then, the brachiopods are long or wide, and short in stature or depressed; while the lamellibranchiates are either long, or high, and narrow or compressed. By way of contrast, then, we might speak of brachiopods as *depressed*, and of lamellibranchiates as *compressed* animals.

The shell of a brachiopod is secreted and formed by the mantle, in which respect it agrees with other bivalves; but it differs from them in containing more extensive evidence of the nature of the internal organisation, a point of the highest importance, since brachiopodous shells yield no small portion of the material upon which the palæontologist has to base his conclusions: and because there are many things to show that exclusive reliance upon the external characters of a shell frequently tends to give a wrong bias to our judgment. Throughout the whole range of the organic world there are no characters which require more caution in the handling than those drawn from external parts only. Instances could be cited by hundreds, indicating that there may be great similarity of external feature combined with highly important differences of structure; and that it is exceedingly difficult to distinguish between analogies and homologies where the evidence is scanty and partial. And we should naturally expect to find that in such a class as the *Brachiopoda*, which is so scantily represented in the living world, and the species of which are mostly founded upon the shell, that frequent mistakes would be committed in grouping together in one genus those shells which have a great resemblance to one another, but which may, nevertheless, have belonged to beings whose plan of structure differed far more widely than would be consistent with assigning them rank in the same genus; and it is not unlikely that cases of this kind are more frequent amongst the lamellibranchiates, but not apparent since they are not detected. In the brachiopods the internal portion of the shell frequently affords a useful check to conclusions drawn from its outside. Thus amongst the *Terabratulidæ* one of the most important characters is the possession of a calcareous loop in the inside of the dorsal valve; and amongst the *Spiriferidæ* the possession of two calcareous spires in the inside of the same valve is a similarly important character, and by means of them alone we can generally distinguish the shells belonging to each family. Thus *Waldheimia*, a terebratuloid genus, presents species which can hardly be distinguished from species of *Centronella*, a spiriferoid genus, so long as attention is confined to external characters. *Waldheimia resupinata* has almost the exact form of *Centronella glansfagea.*

The shell is generally composed of carbonate of lime, combined with even less animal matter than is usually found in other calcareous shells; but there is one remarkable group in which the shell contains very little carbonate of lime, but consists almost equally of phosphate of lime and animal matter. Thus a shell of *Lingula*, analysed by Cloez, when dried at 212° F., contained—

	Per cent.
Organic matter	45.20
Carbonate of lime	6.68
Phosphate of lime	42·29
Phosphate of magnesia	3·85
Phosphate of iron	1·98
Silica	tr.

When the organic matter is excluded, this has considerable resemblance to the composition of the bone of many of the higher vertebrates. The shell of *Discina* is not very different; but those of *Chonetes*, *Leptæna*, &c., are noticeable for consisting mainly of carbonate of lime, with a small proportion only of the phosphate. In some of the strata in which *Lingula* is abundant, such as the Chazy formation of America, the fragments of shells belonging to this genus are associated with black phosphatic nodules, which are sometimes profusely distributed over an area of many square miles, and which it may reasonably be conjectured have been derived in some way from *Lingula* shells. All the members of the families *Discinidæ* and *Lingulidæ* have these phosphatic shells.

The brachiopods may also be arranged in two groups, taking as the basis of distinction the nature of the connection between the two valves. Thus in the *Discinidæ*, *Lingulidæ*, and *Craniadæ*, the valves are kept in position, as well as opened and shut, entirely by muscular agency; while in the remaining families the valves are prevented from sliding forward or laterally by means of projections in the ventral valve, which lock into sockets in the dorsal valve. Associated with this difference, we find that the group with non-articulated valves have a more complex muscular system than that with articulated valves, as will be seen from the following table, in which we have indicated the names which have been long used, and those which were proposed by Mr. Hancock in 1858:—

Names formerly in use.	Names proposed for muscles in unarticulated brachiopods.	Names proposed for homologous muscles in the articulated brachiopods.
Anterior retractors.	Anterior occlusors.	Anterior occlusors.
Anterior adductors.	Posterior occlusors.	Posterior occlusors.
Posterior adductors, or cardinals.	Divaricators.	Accessory divaricators.
	Central adjustors.	Ventral adjustors.
Central protractors.	Exterior adjustors.	
Exterior protractors.	Posterior adjustors.	Dorsal adjustors.
Posterior retractors.	Peduncular.	Peduncular.
Capsular.	Anterior parietals.	
	Posterior parietals.	

The muscles for accomplishing the same object are, in most instances, arranged in pairs. In both groups the valves are separated and brought together by means of the occlusor muscles, which are fixed directly to the interior of each valve, and by the divaricators, which pass obliquely backwards from the ventral valve to be attached to the beak, or to processes in the dorsal valve. The actions of these muscles appear to be to a certain extent complementary to each other. Thus in the case of the occlusors the force is applied for the purpose of shutting the valves, and the valves are separated or less forcibly held in contact by a relaxation of the muscles. Since they act in an almost vertical direction they do not seem to be of themselves capable of actually separating the valves, but only of allowing their separation. On the other hand, the force is transmitted to the divaricator muscles, when it is wished to open the valves. The dorsal valve rests either on the edge of the ventral one, or else upon projections in that valve. The dorsal valve projects somewhat beyond the dental sockets, and to this projection or cardinal process the divaricator muscles are attached. Hence, when these contract, the portion of the valve behind the sockets, or behind the point where the dorsal rests on the ventral valve, is pulled down, and with the teeth or edge of the ventral valve as fulcra, the dorsal valve is lifted above the ventral, the gape being greatest at the anterior end. In the non-articulate group, the divaricator muscles are much assisted by the four parietal muscles, which are said to assist by pressing the fluid in the perivisceral cavity, thus forcing the valves apart. These muscles are of great size. In the articulated brachiopods, the sliding of the valves upon one another, either backwardly or laterally, is prevented by the socketed hinge. In the inarticulate group it is equally prevented by special muscles. Thus in *Lingula* there are three pairs of strong muscles, viz., the adjustors, which are so arranged as to prevent any sliding action. These muscles are also present in the articulated group, but modified in form and number; their principal action appears to be to adjust the valves with reference to the pedicle. The shell is generally attached to some solid substance by means of the peduncular muscles, which pass through a hole (foramen) or notch at the posterior part of the ventral valve. The interior of the valves frequently possess impressions marking the places where some of the muscles were attached. The muscles are fleshy and soft at their expanded ends, but remarkably glistening and tendon-like in the intermediate portion. They are, for the most part, non-striated, but in *Waldheimia* the posterior adductors are transversely striated, and well supplied with nerves.

The structure of the shell itself is a characteristic feature in this class; but, as in several other points, the *Lingulidæ* and *Discinidæ* are marked off from all the other families. In the group with articulate and calcareous valves the shell is formed by long prisms arranged parallel to one another, but obliquely to the surfaces of the shell itself. Internally the ends crop out so as to form an imbricated surface; but externally this is not usually apparent owing to the external surface being covered with a membrane, but it may be seen in specimens which have been somewhat rubbed, as is frequently the case with fossil valves. The prisms resemble those in the lamellibranchiate shell, but differ in being much flattened, and in not being more or less perfectly hexagonal. The shell is in many species traversed by minute perforations, which are somewhat sporadically distributed amongst the class. Their size and number vary considerably, and there is no apparent relation between the diameter of the canals and their density of distribution. Of the recent species the canals are largest and most closely set in *Waldheimia Australis*, the average diameter being $\frac{1}{800}$th of an inch, and average distance from centre to centre $\frac{1}{400}$th of an inch. In *Terebratulina caput-serpentis* the distance from centre to centre is about the same, and the average diameter less than $\frac{1}{1500}$th of an inch. The canals are generally more or less funnel-shaped and simple: sometimes they are bifurcated, as in many of the *Terebratulidæ*, and in a few (*Craniadæ*) they are arborescent or ramified. In the living mollusc these canals, which pass through the shells, are occupied by cæcal processes from the outer surface of the mantle. It is not known what the function of the cæca and perforations are. It is improbable that they are connected with the formation and growth of the shell, since they are absent in some groups; their general distribution over the shell negatives the idea that they discharge the functions of a liver. It has been suggested that they are offshoots from the great vascular sinus which occurs between the body of the mantle and its outer layer, and analogous to the vascular processes which pass from the tunic to the test of an ascidian, a view which is more or less supported as being consistent with our present state of knowledge, by Huxley, Owen, Woodward, and Carpenter. Mr. Quekett observed radiating lines surrounding the apertures which he conjectured might represent cilia. So far as the facts go they seem to us to be not inconsistent with the idea that these parts are subservient to the process of respiration. Perforated shells characterise all the species of some families, in others some of the species only possess them, while in yet others this feature is entirely absent. Thus they are present in all the *Terebratulidæ*; absent in the *Rhynchonellidæ*, and present in some only of the *Spiriferidæ* and *Strophomenidæ*.

Another portion of the shell which affords useful evidence as to the distribution of the soft parts, and the relation of one species to another, consists of the calcareous processes which spring from the hinge of the dorsal valve and are continued forward as more or less complicated loops amongst the *Terebratulidæ*, and spires or whorls amongst the *Spiriferidæ* and *Rhynchonellidæ*. The spires are coiled in a lateral direction in the *Spiriferidæ*, and in a vertical direction in the *Rhynchonellidæ*. They are believed to be present in all the *Spiriferidæ*, but there are many species of *Rhynchonellidæ* in which they are absent. In all the groups with internal calcareous supports there may frequently be found near their origin at the hinge part of the shell two upwardly tending projections, as in *Terebratula*, which mark the approximate position of the mouth. In some genera the processes are developed into loops, through which the œsophagus passes. When the position of these loops, arches, or projections, is observed, as also of the foremost muscular scar, and it is borne in mind that the great bulk of the organs, exclusive of the mantle and arms, is situated behind these, it will be seen how small a space is occupied by the digestive organs, and how much is appropriated by the mantle and arms. The digestive canal presents comparatively little difference throughout the class. It comprises a mouth leading into a narrow œsophagus, a simple stomach, and as simple an intestine. The mouth generally has a lower and an upper lip, and is situated just at the base of the groove or canal which traverses the arms; the lips are provided with a few muscles and glandular-like cells, but there are no rudiments of any dental apparatus, which indicates that no mastication of the food is required. In *Lingula* the alimentary canal commences about the middle of the shell, and proceeds in a nearly horizontal direction almost to the back of the shell. It is reflected in the dorsal direction, and is bent forwards along the side so as to terminate between the mantle lobes. The fæcal matter is there discharged to be carried away by the excurrent passages. There is a similar arrangement in *Discina;* the only important difference being that the intestine is reflected ventrally in passing to the right side. In *Waldheimia* the œsophagus takes an upward direction from the mouth, and passes into the stomach at its upper end. The stomach itself forms the downward portion of the arch, and the intestine is continued in the downward direction, but inclines somewhat backwardly, terminating just behind the adductor muscles. In *Waldheimia flavescens*, and a few other species of the articulate group which have been examined, no anal aperture could be detected; so that the presence or absence of such an aperture appears to be another feature which distinguishes the brachiopods with articulated from those with non-articulated valves. The liver forms a coloured mass about the stomach, and is frequently the most conspicuous viscus; in *Waldheimia flavescens*, for example, it is three times more bulky than the stomach. In the last mentioned species the alimentary canal is short, and the stomach is wide, while in *Lingula* the same canal is very long, and there is no marked difference in the widths of the stomach and other parts.

The following outline of the other systems is taken from the edition of Woodward's 'Manual of Mollusca,' published in 1866:—"The circulatory system is far less complex than was formerly supposed and does not greatly differ from the same system in the *Tunicata*. The heart is placed on the dorsal surface of the stomach, and consists of a simple unilocular pyriform vesicle, without any auricle. From it the blood is propelled through four channels to the organs of reproduction, and to the mantle; and its flow is probably assisted by a number of subsidiary pulsatile vesicles situated on the main arterial trunks. It then courses through the plexus of lacunes of the parietes into the system of visceral lacunes. It probably enters the liver, and ultimately finds its way back into the heart through the branchio-systemic vein. There is, however, another and more important blood current which traverses the whole length of the brachial canal and penetrates to the extremities of the cirri, before it joins the current returning from the visceral lacunes and flows with it into the branchio-systemic vein. The blood which has passed through the brachial canal is far more highly oxygenated than the blood which has flowed through the pallial membrane. There seems to be strong evidence that the so called arms are really the gills or respiratory organs of the mollusc. They also serve to bring food to the creature's mouth by the means before noticed [or by the action of cilia which force the water along the gutter leading from the extremity of the arms into the mouth]. The mantle is an accessory breathing organ. It attains its highest development as such in *Lingula*, but even in this genus the brachial apparatus performs the chief part in oxygenating the blood. There is another system of canals which take their rise from the visceral cavity. What its function is has not been determined : it is not the blood system, as was formerly imagined, and has no connection with it. The perivisceral cavity and the visceral lacunæ which diverge from it may, it is thought, be homologous to the water vascular system in *Polyzoa*, the function of which is probably to evacuate the effete nitrogenised products which have been eliminated from the blood. Consequently it would perform the offices both of the kidney and the renal organs. The generative organs occupy the great pallial sinuses, and probably both sexes are combined in one individual. In the articulated Brachiopods the ovaries and testes are placed in the mantle ; but in *Lingula* and *Discina* they occur in the perivisceral chamber. The ova escape into the oviducts (regarded by Cuvier and others as hearts), which open externally and have nothing to do with the vascular system. In *Rhynchonella* there are four oviducts, but in most if not all the other Brachiopods, there are only two. In *Terebratulidæ* they are divided into two portions, called the auricle and ventricle by Professor Owen. Mature eggs have been found in large numbers in the perivisceral chamber and in the oviducts. Recent *Discinæ* often have minute fry attached to their valves, and Mr. Suess, of Vienna, has noticed a specimen of the fossil *Stringocephalus* which contained numerous embryo shells. As yet we know little respecting the development of the *Brachiopoda*, but there can be no doubt that in their first stage they are free and able to swim about until they meet with a suitable position. It is probable that in the second stage they all adhere by a byssus, which in most instances becomes consolidated and forms a permanent organ of attachment. Some of the extinct genera (e. g., *Spirifera* and *Strophomena*) appear to have become free when adult, or to have fixed themselves by some other means. Four genera, belonging to very distinct families, cement themselves to foreign objects by the substance of the ventral valve. The nervous system exhibits a state of development but little superior to what is found in the ascidians. No special organs of sense have been detected. The red spots in the mantle, supposed by some to be rudimentary eyes and ears, are probably the glands situated at the base of the setæ.”

A few other details may be added to this quotation. In some species the sexes are now known to be developed in different individuals. Professor Owen noticed that the generative organs of a number of individuals of *Waldheimia flavescens* presented a manifest difference of texture and colour. Thus in some the organs were better defined, more compact, and of a paler colour : in others they were broader, more diffused, and of a deeper yellow colour. On submitting them to a microscopic examination it was discovered that ova only were developed in the individuals with the broader and darker coloured organs, and sperm cells in those in which they were narrow and compact.

Next we would notice the embryo brachiopod discovered and described by F. Müller. It was a small orbicular bivalved mollusc, in which the valves were similar in shape, but dissimilar in size, the dorsal being the larger of the two. The valves are not connected by a hinge, but at the part occupied by it in the adult is a small oval plate. The mantle is open all round, and has five pairs of stiff setæ at its margin, four of which originate in the ventral half of the mantle. There are also a series of finer setæ on the margin of the dorsal lobe, which are curved so as to arch over the ventral valve. The embryo is provided with a pair of auditory capsules, and a pair of eyes. The alimentary canal occupies the posterior half of the intervalvular space ; the anterior half being appropriated by four pairs of short cylindrical processes, supported on a common peduncle, and surrounding a knob behind which is the mouth. The cylindrical processes are richly clothed with cilia, and their action enables the animal to swim freely through the water. During locomotion the mouth always occupies a forward position. As this embryo was found in swarms at Desterro, in Brazil, where a species of *Crania* is the only living brachiopod known, the embryo is supposed to appertain to that species. Professor Owen has briefly noticed some embryo *Lingulæ* in a still earlier stage of development ; and a more advanced embryo of the same genus has been described by McCrady, in the ‘Proceedings of the Elliot Society of Charleston.’

The classification proposed by De Blainville has not been adopted, and several other systems have since been drawn up. The following is an outline of a few of these.

D’Orbigny grouped the *Rudistes* and *Brachiopoda* in the same class ; the great bulk of the latter constituted his order *Brachiopoda brachidæ;* while *Argiope* and *Thecidium* were placed along with the *Rudistes* proper in his order *Brachiopoda cirrhidæ*. This view has received little support. The *Brachidæ* are arranged thus :—

Fam. 1. *Lingulidæ.*
Genera : Lingula ; Obolus.

Fam. 2. *Calceolidæ.*
Genus : Calceola.

Fam. 3. *Productidæ.*
Genera : Productus ; Chonetes ; Leptæna.

Fam. 4. *Orthisidæ.*
Genera : Strophomena ; Orthisina ; Orthis.

Fam. 5. *Rhynchonellidæ.*
Genera : Hemithyris ; Rhynchonella ; Strigocephalus ; Porambonites.

Fam. 6. *Uncitidæ.*
Genera : Uncites ; Atrypa ; Pentamerus.

Fam. 7. *Spiriferidæ.*
Genera : Cyrtia ; Spirifer ; Spiriferina ; Spirigerina ; Spirigera.

Fam. 8. *Magasidæ.*
Genera : Magas ; Terebratulina.

Fam. 9. *Terebratulidæ.*
Genera : Terebratula ; Terebratella ; Terebrirostra ; Fissurirostra.

Fam. 10. *Orbiculidæ.*
Genera : Siphonotreta ; Orbicella ; Orbiculoidea ; Orbicula.

Fam. 11. *Craniadæ.*
Genus : Crania.

Argiope and *Thecidium*, which are placed in his order *Cirrhidæ*, should be admitted into the family *Terebratulidæ*. Davidson considers that the *Magasidæ* should also be merged in this family ; and that the *Uncitidæ* should be abolished, the genera *Uncites* and *Atrypa* coming better amongst the *Spiriferidæ*, and *Pentamerus* amongst the *Rhynchonellidæ*. The *Calceolidæ* should also be abolished, since *Calceola* is a coral. This leaves eight families, which approximate to the eight families into which Woodward grouped the class. The following is an outline of his arrangement, in which we have included the names of the sub-genera in parentheses.

Fam. 1. *Terebratulidæ.*
Genera : Terebratula (Terebratulina ; Waldheimia ; Meganteris) ; Terebratella (Trigonosemus ; Lyra ; Magas ; Bouchardia ; Morrisia ; Kraussia ; ? Megerlia ; ? Kingena ; ? Ismenia ; ? Waltonia ; Zellania) ; Argiope ; Thecidium ; ? Stringocephalus.

Fam. 2. *Spiriferidæ.*
Genera : Spirifera (Spiriferina ; Cyrtia ; Suessia) ; Athyris (? Merista) ; Retzia ; Uncites.

Fam. 3. *Rhynchonellidæ.*
Genera : Rhynchonella (? Porambonites ; Camarophoria) ; Pentamerus ; Atrypa.

Fam. 4. *Orthidæ.*
Genera : Orthis (? Orthisina) ; Strophomena (? Leptæna ; Koninckia) ; Davidsonia ; Calceola.

Fam. 5. *Productidæ.*
Genera : Productus (Aulosteges) ; Strophalosia ; Chonetes.

Fam. 6. *Craniadæ.*
Genus : Crania.

Fam. 7. *Discinidæ.*
Genera : Discina (Trematis) ; Siphonotreta (? Acrotreta).

Fam. 8. *Lingulidæ.*
Genera : Lingula ; Obolus.

In the following outline of Davidson’s scheme the sub-genera are placed in parentheses.

Fam. 1. *Terebratulidæ.*
Genera: Terebratula (Terebratulina; Waldheimia); Terebratella (? Trigonosemus; ? Terebrirostra; Megerlia); Kraussia; Magas; Bouchardia; Morrisia; Argiope.

Fam. 2. ? *Stringocephalidæ.*
Genus: Stringocephalus.

Fam. 3. *Thecideidæ.*
Genus: Thecidium.

Fam. 4. *Spiriferidæ.*
Genera: Spirifer (? Spiriferina; ? Cyrtia); Athyris; Spirigera (? Retzia); Uncites; Atrypa.

Fam. 5. ? *Koninckinidæ.*
Genus: Koninckina.

Fam. 6. *Rhynchonellidæ.*
Genera: Rhynchonella; Camarophoria; Pentamerus.

Fam. 7. ? *Porambonitidæ.*
Genus: Porambonites.

Fam. 8. *Strophomenidæ.*
Genera: Orthis; Orthisina; Strophomena; Leptæna.

Fam. 9. ? *Davidsonidæ.*
Genus: Davidsonia.

Fam. 10. *Productidæ.*
Genera: Chonetes; Strophalosia (? Aulosteges); Productus.

Fam. 11. *Calceolidæ.*
Genus: Calceola.

Fam. 12. *Craniadæ.*
Genus: Crania.

Fam. 13. *Discinidæ.*
Genera: Discina (Orbiculoidea; Trematis); Siphonotreta (Acrotreta).

Fam. 14. *Lingulidæ.*
Genera: Lingula: Obolus.

The following descriptions of the genera are compiled from Davidson's 'Monograph of the British Brachiopoda,' vol. i.; modifications are introduced at places in accordance with more recent information:—

Family I. TEREBRATULIDÆ.

Animal fixed to submarine bottoms by a muscular peduncle issuing from a perforation in the beak of the larger valve; this aperture is partly surrounded by a deltidium in one or two pieces; oral appendages entirely or partially supported by calcified processes which commonly assume the shape of a loop, variable in form and dimensions, but always fixed to the smaller or dorsal valve; shell structure always punctated.

Terebratula. Llhwyd, 1696.—Shell oval, elongated, or transverse, externally smooth or plaited; valves more or less unequally convex; margin even or waved: hinge line curved, beak short, truncated by a foramen, variable in size, and partly margined by a deltidium in one or two pieces; loop short, confined to the posterior portion of the shell, and not exceeding much more than a third of the length of the valve, simply attached to the hinge plate. The two riband-shaped lamellæ are soon united by a transverse lamella, bent upwards in the middle. The cirrated arms are supported by the crura and project considerably in front of the loop; no internal septum in the socket valve.

Terebratulina. D'Orbigny, 1847.—Shell generally longer than wide, and more or less oval. Beak obliquely truncated by a foramen, which generally extends to the umbo; deltidium small, and at times indistinct; socket or dorsal valve less convex than the perforated one, exhibiting two variably developed auricular expansions; surface striated or costellated; valves articulating by means of teeth and sockets; loop short, not exceeding one-third of the length of the shell, and rendered annular by the union of the oral processes in the shape of a shelly band. The cirrated arms are supported by the crura, and project considerably into the interior of the shell; structure punctated.

Waldheimia. King, 1849.—Shell variable in shape, more or less circular, subquadrate, transverse, or elongated, with both valves convex, or with the smaller or dorsal one depressed or concave; margins straight or waved; surface smooth or plaited; beak truncated, and perforated by a circular foramen of variable dimensions, partly completed by a deltidium in one or two pieces; loop long, in general exceeding two-thirds of the length of the valve, formed of slender, shelly, riband-shaped lamellæ simply attached by the crura to the hinge plate, and more or less folded back upon itself. The cirrated arms are partially supported by this appendage, and united throughout by a membrane, exactly as in the typical species of *Terebratula.* The valves articulate by means of teeth situated one on each side of the deltidium, supported by plates, and fitting into corresponding sockets in the smaller or dorsal valve. In the interior of the smaller valve a prominent cardinal process or boss and hinge plate, with four depressions, occupies the space between the socket ridges, under which originates a central mesial septum, which extends more or less into the interior of the shell; structure punctated.

Terebratella. D'Orbigny, 1847.—Shell elongated or transverse, variable in shape: both valves regularly and unequally convex, or interrupted by a longitudinal depression in the smaller valve; beak truncated by an oblique foramen of a circular or oval form, and partly margined by a deltidium in two pieces, at times disunited above the umbo; beak ridges more or less defined, and in some cases leaving between them and the hinge line a flat or concave cardinal area; external surface smooth or variously punctated; hinge articulating by means of teeth in the larger and sockets in the smaller valve. In the interior of the dorsal valve, under the cardinal process and hinge plate, a more or less elevated medio-longitudinal crest or septum extends to about half the length of the valve; the loop is elongated and doubly attached, first to the hinge plate, and afterwards to the mesial septum, by processes given off at right angles near the centre of the valve, the remaining portion soon after becoming reflected. The double impressions of the adductor are seen on either side near the mesial plate.

Trigonosemus. König, 1825.—Shell inequivalve, oval, transverse or elongated; dental valve always convex, smaller one moderately so, flat or longitudinally depressed; beak produced, recurved, and truncated by a small foramen originating at the summit of the beak, and extending on the opposite side to the area. This last is large, margined and carinated exteriorly; the deltidium occupying less than a third of the surface, a small portion only edging the foramen; external surface striated or variously costated; hinge articulating by the means of teeth and sockets; between the socket ridges a remarkable large and produced cardinal process or boss fills a cavity in the beak of the larger valve; the loop is doubly attached, first near the base of the socket ridges, and afterwards to a short mesial septum before becoming reflected; the adductor muscular impressions are deeply indented on either side close to the base of the septum.

Terebrirostra. D'Orbigny, 1847.—Animal unknown. Shell more or less oval, inequivalve; beak considerably elongated, almost straight, with a false area and narrow deltidium; valves articulating by the means of teeth and sockets; internal arrangements of the calcified supports of the arms unknown; a mesial septum exists in the interior of the smaller valve; cardinal process large and produced; external surface plaited.

Megerlia. King, 1849.—Shell inequivalve, suborbicular, transverse, or longitudinally oval; beak short, and truncated by a circular foramen; deltidium small; beak ridges well defined; external surface smooth, spinulose, or covered by fine radiating striæ; shell structure largely punctated; hinge line sometimes long and straight, with the articulating teeth and sockets widely separate. In the interior of the socket or dorsal valve a slightly elevated medio-longitudinal septum proceeds from under the cardinal process or boss to less than half the length of the valve; the loop is three times attached, first to the base of the socket ridges, afterwards by a horizontal process to near the extremity of the septum, and again by two additional processes departing from the reflected portion of the loop to the central septum. The cirrated arms are large, their fringes extending to near the border of the shell; on either side of the mesial septum are seen the double scars produced by the adductors.

Kraussia. Davidson, 1852.—Shell subcircular, with a nearly straight hinge line; beak truncated; foramen large, round; deltidial plates small, not united; beak ridges well defined, leaving a flat false area between them and the hinge margin; in most species a longitudinal depression exists in the smaller valve; external surface smooth, or variously plaited; structure punctated; the dorsal pedicle muscles produce two wide egg-shaped impressions close to the hinge, and between the inner walls of the socket ridges a small, slightly elevated mesial ridge extends to about half the length of the valve, at the extremity of which arise two small forked diverging lamellæ, expanded at their extremity. The cirrated arms are unusually small, their fringes not extending more than half way towards the border of the shell; in the first part of their course from the mouth forward the cirrhi are few or wanting; the whole brachial apparatus is supported by the small forked process above described, no other part of the apophysary system being calcified; cardinal process or boss small.

Magas. Sowerby, 1818.—Animal unknown. Shell small, inequivalve, more or less regularly oval; beak truncated by a foramen extending to the umbo of the smaller valve; surface smooth or slightly striated; shell structure largely punctated; apophysary system in the dorsal or socket valve composed of an elevated longitudinal septum reaching from one valve to the other, and to which are affixed two pairs of calcareous lamellæ; the lower ones are riband-shaped; attached first to the hinge plate, they afterwards proceed by a gentle curve to near the anterior portion of the septum, to the sides of which they are affixed; the second pair originate on either side of the upper edge of the septum, extending in the form of two triangular anchor-shaped lamellæ.

Bouchardia. Davidson, 1849.—Shell of an elongated oval shape; valves thick, and almost equally convex; beak nearly straight, and truncated by a small circular foramen; no true area or deltidium; external surface smooth; structure punctated; valves articulating by means of teeth and sockets. In the interior of the smaller or dorsal valve the socket ridges are largely developed, extending to nearly a third of the length of the valve, and fitting into corresponding grooves in the dental valve; the hinge plate or platform is large and massive, filling up the space between the socket ridges; and from the extremity of the umbonal beak originates the cardinal process or boss, which assumes the shape of two deviating elongated crests grooved along their upper surface, and probably serving as an attachment to the cardinal muscles; pedicle scars are visible on the outer sides of these; at the base of the platform above described a short mesial septum gradually arises, to the upper edge of which is affixed an anchor-like pair of lamellæ, and close to the base of the septum was attached the adductor muscle. In the dental valve a mesial ridge separates the large cardinal muscular scars placed on either side, and towards the centre of the valve a small ovate impression indicates the place of the adductor. The ventral pedicle muscles occupy a deep groove, which extends from the last-named scar to the extremity of the foramen, which is excavated in the substance of the beak.

Morrisia. Davidson, 1852.—Shell minute, circular, depressed; foramen large, round, encroaching equally on both valves; large or dental valve with a small straight hinge area: deltidium plates minute, widely separated: valves articulating by means of teeth and sockets; smaller or socket valve deeply notched at the umbo: apophysary system consisting of two branches, originating at the base of the dental sockets, and united to a small elevated process arising from the centre of the valve. Animal furnished with two subspiral or sigmoid arms, fringed with comparatively large cirrhi: these arms originate beside the mouth, supported by the crural processes, and after passing forwards and converging in front of the mouth, they again turn outwards, each having the shape of the letter S: external surface smooth and largely punctated.

Argiope. Deslongchamps, 1842.—Shell semi-orbicular, quadrate or transversely oval: valves unequally convex, smooth or variously costated: ventral or dental valve the deepest, beak produced, with a depressed triangular area: foramen large, completed by the umbo of smaller valve: hinge line straight: valves articulating by means of teeth and sockets. Interior of smaller valve furnished with a central septum, and sometimes with one or more lateral septa radiating from beneath the cardinal muscular prominence, and terminating at some distance from the margin in elevated processes; apophysary system consisting of a distinct loop, originating at the base of the dental sockets, and folded into two or more lobes occupying the interspaces of the radiating septa, to which they adhere on their inner sides: the labial processes or arms originate on the sides of the mouth, and diverge right and left parallel with the margin of the shell, but at some little distance from it; when they arrive at the raised septa, they turn inwards, forming one or more lobes on each side of the middle line, but on reaching the central septum they become perhaps free at their extremities. The mantle adheres closely to the shell, and is not seen except as a part of it.

Sub-family Stringocephalidæ.

Animal unknown, attached during the greatest part of its existence by means of a muscular peduncle; labial appendages supported by a largely developed calcified process or loop: a mesial septum, small in the dorsal, large in the ventral valve. Cardinal process extending to the ventral septum: shell structure widely punctated.

Stringocephalus. Defrance, 1827.—Shell transversely or longitudinally oval, valves unequally convex: beak acute, entire, and slightly incurved: area defined and divided in young individuals by a large triangular fissure, which is afterwards reduced to an oval foramen, entirely surrounded by a deltidium, and finally closed in some adult individuals: external surface smooth; valves articulating by the means of a large tooth, situated on either side of the deltidium, close to the hinge line, and fitting into corresponding sockets in the smaller valves. In the interior of the ventral valve a large mesial longitudinal septum extends to within a short distance of the frontal margin: this plate is thick at its origin and base, but gradually decreases in width while increasing in depth, as it recedes from near the extremity of the beak. In the smaller or dorsal valve a massive curved cardinal process stretches to the opposite valve, where it clasps the ventral mesial septum with its bifurcated extremity: near the base of this process in the dorsal valve a longitudinal septum arises (smaller than that of the ventral valve), and which divides the quadruple impressions of the adductor muscle: the socket walls are very much expanded, forming prominent hinge-plates curving inwards on each side of the cardinal process. The lower portion of the hinge plate supports the crura of the loop in the shape of two flattened stems or lamellæ, which, after proceeding with a slight upward curve to near the extremity of the septum, are suddenly reflected, and again approach the sockets before sweeping submarginally round in the shape of a large wide loop, from the inner edge of which a number of smaller lamellæ branch off and converge.

Family II.—Thecideidæ.

Shell generally thick, fixed to marine objects by the substance of the beak of the larger or ventral valve; mantle adhering to the inner surface of the shell; the oral processes united in the form of a bridge over the visceral cavity; cirrated arms folded upon themselves, and supported by a calcareous loop or apophysary ridge more or less complicated in its details; shell structure punctated.

Thecidium. Defrance, 1828.—Shell thick, subquadrate, triangular, oblong, or transversely oval; dental or ventral valve most convex, partially or entirely attached to submarine bottoms by the substance of the shell of its larger or ventral valve; beak straight or recurved with a more or less defined false area and pseudo-deltidium; smaller or dorsal valve slightly concave or convex, likewise at times exhibiting a narrow false area; external surface smooth or variously striated, the lines of growth passing uninterruptedly over the valves and false area; shell articulated by means of teeth and sockets. Interiorly a thickened granulated margin generally encircles the valves, which, in the dental one, after reaching the front, extends inwards in the shape of a rounded mesial ridge; in the small free cavity of the beak, and beneath the deltidium, are seen three short elevated septa, the central one slightly exceeding the lateral ones; under these are situated two small contiguous elongated oval scars, probably due to the adductor, and, on the outer side of these, other two elongated impressions left by the cardinal muscles. The internal details of the socket or dorsal valve vary considerably both in species and age; the cardinal process or boss is more or less produced—the inner socket walls project considerably, and are connected by a small bridge or arch-shaped process; the interior of the valve is more or less deeply and regularly furrowed to receive a testaceous ridge folded into two or more lobes. This loop or apophysary ridge supports the brachial membrane, whose thickened and cirrated margin is apparently supported by the inner side of the sinuous grooves; animal small, with the mantle lobes disunited and adhering closely to the valves; shell structure punctated.

Family III.—Spiriferidæ.

Animal free or rarely attached by a muscular peduncle; oral appendages largely developed and entirely supported by a thin shelly spirally-rolled lamella; shell structure either punctated or unpunctated.

Spirifer. Sowerby, 1815.—Animal unknown; shell somewhat trigonal; transverse or elongated; inequivalve, with or without a mesial fold and sinus; hinge line shorter or longer than the width of the shell; cardinal angles obtusely rounded or extended into wing-shaped expansions; external surface smooth, or variously costated; shell structure unpunctated; valve articulating by means of teeth and sockets; beak straight or recurved; area in ventral valve large or narrow, and nearly parallel-sided; bent backwards, flat or concave, and divided by a triangular fissure, always more or less closed by a pseudo-deltidium notched in the vicinity of the cardinal edge; area in the dorsal valve narrow, often linear, and likewise divided by a wide open fissure, partly or entirely occupied by the cardinal process or boss. In the interior of the smaller valve the labial appendages were supported by calcified lamellæ, assuming the shape of two large conical spires, which nearly fill the interior of the shell; the ends of the spires are directed outwards towards the cardinal angles; the bases of the hollow conical spires nearly meet at the hinge-side, but are wide apart in front; the hinge plate is divided into two portions, to which the crura of the spires are attached; the crura are united, at some distance from the hinge, by an oral lamella; the divisions of the hinge are hollowed, perhaps for the reception of the pedicle muscles; the cardinal muscles were no doubt fixed to the cardinal process or boss, which is small, and situated in the notch of the hinge-plate; under it are seen four large elongated scars left by the adductors. In the interior of the large valve a short hinge-tooth is situated on either side at the base of the fissure, supported by vertical shelly plates, which extend from the beak to the bottom of the valves, thus forming the fissure walls, and assuming various forms and directions in different species; they are either small, regularly diverging, or converging to diverge again, and extending a greater or less distance into the interior of the valve; between these a great portion of the free space at the bottom of the shell is filled up by muscles, which are generally divided by a blunt longitudinal crest; the adductor commonly producing a small longitudinal and mesial oval scar, and on either side of which are situated the cardinal muscles: pedicle impressions cannot be detected in this valve.

Spiriferina. D'Orbigny, 1847.—Shell generally transverse; valves unequally convex, with or without a mesial fold; surface smooth or costated; beak straight or recurved; area commonly largely developed, and interrupted by a pseudo-deltidium notched in the vicinity of the cardinal edge; shell structure punctated; surface spinose; hinge line commonly shorter than the width of the shell; valves articulating by means of a strong cardinal tooth situated on each side at the base of the fissure, supported by strong, largely developed vertical shelly plates, and corresponding with sockets in the interior of the smaller valve; the space intervening between the dental plates in the interior of the ventral valve is occupied by the cardinal muscles, which are divided by an elevated mesial septum, wide and thick at its base, but gradually tapering into the shape of an ovate blade, to the sides of which the adductor was, no doubt, fixed; in the interior of the dorsal valve the shelly lamellæ destined to support the cirrated arms assume the form of two large spiral horizontal cones.

Cyrtia. Dalman, 1827.—Shell somewhat trigonal; valves convex; hinge line nearly as long as the width of the shell, articulating by means of teeth and sockets; dental or ventral valve very deep, more or less pyramidal; beak straight, or slightly recurved; area wide and triangular; fissure entirely covered by a convex pseudo-deltidium in one piece, generally perforated extremely close to the beak by a circular foramen; sometimes this deltidium is longitudinally depressed along its centre, from the extremity of the beak to within a variable distance of the cardinal edge; at the extremity of this shallow groove is seen a small circular aperture, which up to a certain age afforded passage to pedicle muscular fibres; the socket or dorsal valve is very slightly convex, and is supposed to have been furnished internally with spiral cones; in the large valve a mesial longitudinal septum extends from the extremity of the fissure to within a short distance of the margin, and to the sides of which the dental plates converge and are united after having formed the fissure walls.

Nucleospira. Hall, 1859.—Professor Hall's description is as follows:—Shell spheroidal or transversely elliptical, more or less gibbous or ventricose, furnished with internal spires, as in *Spirifer*; hinge line shorter than the width of the shell; cardinal extremities rounded; valves subequal, articulating by teeth and sockets; ventral valve having the beak extended beyond the opposite valve, and beneath it a triangular depression or area, which sometimes terminates in a shallow spoon-shaped pit, on each side of which at the base is a strong tooth. A narrow ridge or septum extends along the centre of the inner side of the valve from beak to base. Dorsal valve furnished with a strong spatulate cardinal process, which, rising vertically from the cardinal margin, is closely grasped at its base by the cardinal teeth of the other valve; and thence bending abruptly upwards, and expanding, is projected into the cavity of the opposite beak, lying close upon the under side of the false area. This process is grooved or depressed in the centre of the upper side, so as to leave between it and the arch of the ventral beak a narrow space for the passage of a pedicle, for the protrusion of which a minute foramen is sometimes observed in the beak. From the sides of this process, above the junction of the teeth of the opposite valve, and at the point where it bends upwards, originate the crural processes which support the spires. A deep cavity beneath the cardinal process extends to the dorsal beak, from which originates a thin elevated septum, running to the base of the shell. Muscular imprints confined to a narrow oval space. Surface apparently smooth: under a lens, punctate; shell structure dotted, and when perfect covered with minute hair-like spines.

Athyris. McCoy, 1852.—Animal unknown; shell of a variable shape, circular, elongated, or transverse; valves more or less unequally convex, with or without a mesial fold and sinus; beak apparently imperforated in the adult, incurved, and in general overlying the umbo of the smaller valve; no area or defined beak ridges; valves articulating by teeth and sockets; external surface commonly smooth. In the interior of the larger or ventral valve, the dental plates are fixed to and along the sides of a longitudinal prominence or convex arcuate plate, which extends to less than a third of the length of the shell, with its narrow end fitting into the extremity of the beak, and its lateral diverging edges to the bottom of the valve. In the free medio-longitudinal region, between the gradually declining base, or prolongations of the condyle plates, were situated the cardinal and adductor muscles; this last has left a small elongated, heart-shaped scar, under and along the outer sides of which are seen the much larger oval impressions of the adjustor muscles. The interior of the smaller or dorsal valve is partly divided by a large, deep, longitudinal septum, which extends from the extremity of the umbo to about two-thirds of the length of the shell, supporting at its origin the hinge plate, which is divided into two portions by a narrow, gradually widening channel; to the socket edges are affixed the spiral cones, the extremities of which are directed toward the lateral margins of the shell; on either side of the septum are seen two muscular scars formed by the adductor.

Meristella. Hall, 1860.—In the 'American Journal of Science and Art,' Second Series, vol. xxxvi. p. 11, Professor Hall describes this genus as including the terebratuloid or athyroid forms which are ovoid and more or less elongated. The shells are sometimes elliptical in outline, and not unfrequently transverse or sub-circular. The valves are unequally convex, with or without a median fold and sinus. Beak of ventral valve more or less incurved (when closely incurved it is apparently imperforate), terminated by an aperture, the lower side of which may be formed by the umbo of the dorsal valve, or by a deltidium. Valves articulating by teeth and sockets. Surface smooth, or marked by fine concentric lines of growth, not lamellose, and indistinct or obsolescent radiating striæ, which are usually more conspicuous in the cast or exfoliated surface than on the exterior. Shell structure fibrous. The ventral valve is much thickened on each side towards the beak, and the rostral cavity is margined by flattened dental lamellæ, which extend downwards to the commencement of the muscular expansions, and terminate at the edge of the shell in blunt teeth-like processes. The muscular impression forms a somewhat broadly triangular depression in the valve just below the rostral cavity. In the dorsal valve is a strong hinge plate or process, the prominent part of which is broadly triangular, somewhat depressed or spoon-shaped in the centre, and supported below by a median septum, which reaches from one-third to one-half the length of the valve, and is marked on each side by deep dental fossets, while the anterior angles are produced into the crura which support the internal spires. Spires arranged in double cones, with the apices directed outwards. From the lower lateral margins of the cardinal process or hinge plate there is a callosity extending beneath and anterior to the dental fossets, and joining with the thickened margin of the valve. It differs from *Athyris* in being smooth, not lamellose, on the exterior surface; in the character of the muscular impressions; in the hinge line; and in the rudimentary median septum.

Retzia. King.—It possesses a punctate terebratula-like shell. The beak is truncated by a round foramen, which is bounded on one side by a deltidium. The hinge area is small, triangular, and well defined. The interior is provided with spires, arranged like those of *Athyris.*

Spirigera. D'Orbigny, 1847.—Animal unknown. Shell inequivalve and variable in shape; circular, subquadrate, elongated, transverse, globose, or depressed, with internal spires; valves articulating by teeth and sockets; beak short, more or less incurved, and truncated by a small round aperture lying contiguous to the umbo of the socket-valve, or separated by a deltidium in two pieces; no true area; beak ridges more or less defined; valves convex, and divided or not by a mesial fold and sinus; surface smooth, striated or variously costated, and marked by numerous concentric lines of growth, sometimes produced considerably beyond the margin of the shell in the shape of foliaceous expansions. In the interior of the smaller or dorsal valves, the hinge-plate presents four depressions or pits, which afforded attachment to pedicle muscles; and close to the extremity of the umbo, a small circular aperture appears at times to communicate with a cylindrical tube, which, after originating under the platform, extends longitudinally and freely, with a slight upward curve, to about a third of the length of the valve; to the inner extremities of the socket ridges are affixed the spiral horizontal cones, with their extremities directed towards the lateral margins of the shell; the crura appear to have been united before the lamellæ commence their spiral coils; no defined septum is visible along the bottom of the valve, but a minute rudimentary mesial ridge which divides the quadruple impressions of the adductor. In the large or ventral valve the dental plates are more or less developed, exhibiting on and close to their inner sides, impressions of the pedicle muscles; the adductor leaves a small oval scar, separated by a minute mesial elevation, under and outside of which are seen two other larger impressions due to the cardinal muscles.

Uncites. Defrance, 1828.—Animal unknown. Shell oval, elongated; valves nearly equally convex; beak long, produced, tapering and incurved at its extremity, hollow and truncated in young specimens by a small oval foramen; no true area; a large concave deltidium partly surrounds the aperture and extends to near the cardinal edge; the umbo of the socket-valve is considerably incurved and concealed by and under the deltidium of the other valve; the sides of the beak as well as of the umbo become in some examples considerably deflected inwards, producing deep, lateral, elongated, concave depressions or pouches, opening externally, and not communicating with the interior; valves articulating by means of teeth and sockets. In the interior of the smaller valve the calcified supports of the arms form two conical spires, attached close to the socket walls by crural processes; surface smooth or striated.

Atrypa. Dalman, 1827.—Animal unknown. Shell circular, transverse, or elongated, furnished with internal spires, valves articulating by teeth and sockets; beak produced or incurved, and slightly truncated by a small opening, separated or not from the hinge line by means of a deltidium; false area at times well defined; dental valve convex or almost flat, with a longitudinal depression or sinus; socket valve convex, with or without a mesial fold; surface smooth, striated, or variously costated and imbricated by squamose lines of growth, often produced considerably beyond the margin, under the shape of tubular spires or foliaceous expansions; structure fibrous and impunctate; spiral appendages originating at the base of the socket walls, and forming two large hollow cones placed horizontally, with their apices directed inwards and towards the hollow of the same valve, which they almost fill; the inner sides of the spires are pressed together and flattened, with their terminations close to each other near the centre of the bottom of the shell. In the interior of the socket valve the quadruple impressions of the adductor muscle are separated by a medio-longitudinal ridge; the pedicle muscles were probably affixed to the two small cardinal plates. In the dental valve at the base of the teeth a semicircular ridge curves on each side, forming a saucer-shaped depression, open in front, and into which were implanted the shell and pedicle muscles; the cardinal muscles seem to occupy the largest portion of the depression, and to have been divided by an obscure mesial ridge; beyond these and a little higher up are placed the pedicle muscular impressions, and above the mesial ridge, nearer the beak, is seen the oval scar left by the adductor. The vascular impressions in the dental valve consist of two principal trunks originating on each side between the cardinal and pedicle muscles; these soon divide into two primary branches, which extend right and left almost parallel to the margin, giving off, at variable intervals, smaller bifurcating veins, which are directed towards the edge of the shell.

Family IV. KONINCKINIDÆ.

Animal unknown. Shell free; valves unarticulated (?); oral arms supported by two lamellæ, spirally coiled.

Koninckina. Suess, 1853.—Shell nearly circular, inequivalve, compressed; larger or ventral valve convex or gibbous, with a slight longitudinal depression; beak considerably incurved, with auricular expansions; smaller or dorsal valve concave, following the curves of the other; surface smooth: no area or deltidium; valve unarticulated (?); in the interior of the dorsal valve a mesial ridge extends from the cardinal process to the frontal margin; arms or oral appendages supported by a spiral calcified lamella (?).

Family V. RHYNCHONELLIDÆ.

Animal free or attached by a muscular pedicle issuing from an aperture situated under the extremity of the beak in the larger or ventral valve; oral appendages spirally rolled, flexible, and supported only at their origin by a pair of short curved shelly processes; structure fibrous and impunctate.

Rhynchonella. Fischer, 1809.—Animal free or attached to submarine objects by means of a pedicle; visceral mass confined to a small space near the umbones, and separated from the general cavity of the shell by a strong aponeurotic membrane. The mouth is situated in the centre of this membrane, supported by the apophysary processes of the dorsal valve; the upper lip is plain, the lower cirrated; both are united at the sides of the mouth, and form long appendages (or labial arms) coiled up spirally, with their ends directed inwards towards the cavity of the dorsal valve. The alimentary canal takes the same course as in *Terebratula australis*, passing through the deeply notched hinge-plate, and ending behind the point of insertion of the adductor muscle in the centre of the ventral valve. The pallial veins are much narrower than in *Terebratula*, and more angular in the mode of bifurcation: there are four principal branches in each lobe, opening into large sinuses similar to those of *Orthis* and *Strophomena*, but smaller in extent. The margin of the mantle is fringed with a few short horny setæ. The muscles are essentially like those of *Terebratula:* their impressions are referred to in the description of the shell. Shell inequivalve, variable in shape, transverse or elongated, circular or trigonal; valves more or less convex, with or without a mesial fold and sinus; beak entire, acute, horizontal, or so much incurved as to leave no free space for the passage of the pedicle muscles; foramen variable in its dimensions and form, placed under the beak, exposed or concealed, entirely or partially surrounded by a deltidium, the aperture being sometimes completed by a portion of the umbo of the smaller valve; deltidium in two pieces, at times either extending in the form of a tubular expansion or rudimentary; surface striated or plaited, rarely smooth; structure fibrous, impunctate. Valves articulating by means of two teeth in the larger (ventral) and corresponding sockets in the imperforated (dorsal) valve; apophysary system in smaller or dorsal valve composed of two short, flattened and grooved lamellæ, separate and moderately curved upwards, attached to the deeply divided hinge plate; in the socket valve the quadruple impression of the adductor muscle is clearly defined and separated by a short medio-longitudinal ridge; the pedicle scars occupy the small cardinal plates, between which is the small and narrow cardinal process. In the perforated valve the two strong diverging cardinal teeth are supported by dental plates extending to the bottom of the valve, and at the base of these a semicircular ridge curves on each side, forming a more or less defined saucer-shaped depression, into which were affixed the shell and pedicle muscles: these last leave two narrow elongated scars, close to the inner base of the dental laminæ, the remaining and largest portion being chiefly occupied by the cardinal muscles, which are longitudinally divided by a small raised ridge; above these again is seen a small oval scar due to the adductor.

Camarophoria. King, 1844.—Animal unknown. Shell of a subtrigonal shape, with convex valves longitudinally divided by a sinus and mesial fold; beak entire, acute, more or less incurved, under the extremity of which a small fissure is sometimes exposed; no area or deltidium; surface generally plaited, with or without marginal expansions; shell structure impunctate;

valves articulating by means of teeth and sockets. In the perforated valve the dental plates are conjoined at their dorsal margins, forming a trough-shaped process affixed to a low medio-longitudinal plate. In the smaller valve the space between the sockets is occupied by a small cardinal muscular protuberance or boss, on either side of which two long slender processes curve upwards, to which were no doubt attached the free cirrated spiral fleshy arms; from beneath the cardinal process a high vertical mesial septum extends to a little more than a third of the length of the valve, supporting along and close to its upper edge a spatula-shaped process, considerably dilated towards its free extremity, and projecting with a slight upward curve to nearly the centre of the shell.

Pentamerus. Sowerby, 1813.—Animal unknown. Shell ovate, somewhat pentagonal, elongated or transverse, and articulated by means of teeth and sockets, rarely with any hinge line or area; dental or ventral valve in general the most curved, with or without a mesial fold or sinus; beak acute, entire, and much incurved, concealing a triangular fissure rarely exposed except in the young state, and over which the umbo of the socket is greatly incurved; no area or deltidium; exterior smooth, striated, or ribbed. Inside the larger valve two contiguous vertical septa coalesce into one median plate extending from the beak to a greater or less distance, and then diverge and form the dental plates, enclosing a triangular chamber of much smaller dimensions than the lateral ones. In the interior of the smaller valve, instead of a single median plate, there are two distinct longitudinal septa of variable dimensions (between which a small median ridge is occasionally found); to these the socket walls converge and join, forming two more or less developed and inclined plates, to the produced extremities of which were affixed the spiral cirrated arms. These plates often form a deep V-shaped chamber corresponding with the similar chamber in the opposite valve, and the edges of the two chambers are applied against each other, so as to leave a rhomboid cavity between them.

Stricklandinia. Billings, 1859.—The following is the original description of the genus ('Canadian Naturalist and Geologist,' vol. iv.):—Shell usually large, elongate oval, transversely oval, or circular, sometimes compressed; valves nearly equal; a short mesial septum in the interior of the ventral valve, supporting a small triangular chamber beneath the beak, as in *Pentamerus;* in the dorsal valve no longitudinal septa, spires, nor loop yet observed; the whole of the internal organs (so far as is yet known), consisting of two very short or rudimentary socket plates, which bear prolonged calcified processes for the support of the cirrated arms. In all the species known the ventral valve has an area more or less developed. The valves articulate by teeth and sockets.

Sub-family ?—PORAMBONITIDÆ.

Animal unknown, but evidently attached, at least during a portion of its existence, by a muscular pedicle; no calcified process for the support of the oral appendages, which were probably fleshy and spirally coiled. In the interior of each valve two diverging septa originate from within the beaks; structure fibrous and impunctate.

Porambonites. Pander, 1830.—Animal unknown. Shell circular, transverse, or elongated; globose, sub-equivalve; valves articulating by teeth and sockets; beaks slightly unequal, rather more produced in dental valve, with a small area in each, generally rudimentary, and perforated by a mesial elongated transverse fissure, which truncates the beak of the larger valve before extending to the hinge line; surface pitted, but the shell structure impunctate; in the interior of larger or ventral valve the dental plates form two slightly elevated and diverging septa, extending to a greater or less distance along the bottom of the shell. In the other valve the socket plates form likewise diverging septa, extending also to a variable distance.

Family VI.—STROPHOMENIDÆ.

Animal unknown. Some of the groups appear to have lived free; others were fixed during the whole or a portion of their existence by means of a muscular pedicle; no calcified supports for the arms, which were no doubt fleshy, and spirally coiled; shell with a straight hinge line, and a low triangular area in each valve; valves both convex, or with the dorsal or ventral one concave or convex; shell structure fibrous or punctated.

Orthis. Dalman, 1827.—Shell variable in shape, sub-circular, or quadrate; valves equally or unequally convex; socket valve sometimes slightly concave, with or without a mesial fold or sinus; hinge line straight, generally shorter than the width of the shell; both valves furnished with an area divided by a triangular open fissure for the passage of the pedicle fibres; beaks more or less incurved, that of the larger valve generally more produced; surface smooth, striated, or ornamented by simple, bifurcated, or intercalated ribs; structure minutely or largely punctated; valves articulating by means of teeth and sockets. In the interior of the larger or ventral valve the vertical dental plates form the walls of the fissure, and extend from the beak to the bottom of the shell; between these a small, rounded mesial ridge divides the muscular scars which extend over two elongated depressions, margined on their outer side by the prolonged bases of the dental plates; the cardinal muscles appear to have occupied the greater portion of the anterior division of these two depressions, the pedicle muscle occupying the external and posterior part of the same space; the adductor was probably attached to each side, and close to the mesial ridge. In the socket valve the fissure is partially or entirely occupied by a more or less produced simple shelly process, to which were affixed the cardinal muscular fibres; the inner socket walls are considerably prolonged into the cavity of the shell, under the shape of projecting laminæ, to the extremity of which free spiral fleshy arms may, perhaps, have been affixed; under this shelly process a longitudinal ridge separates the quadruple impressions of the adductor, which on each side forms two deep oval depressions, placed obliquely one above the other, and separated by lateral ridges branching from the central one; the pallial vessels, as well as their numerous minor bifurcations or veins, have often left impressions within the valves; the principal trunks seem both more numerous and better defined in the socket valve; after extending in a somewhat radiate or sub-parallel direction from the muscular scars to near the anterior region, they sweep round sub-marginally on both sides of the valve, leaving wide ovarian spaces, and giving off a series of smaller branches.

Orthisina. D'Orbigny, 1849.—Animal unknown. Shell semicircular or subquadrate, with unequally convex valves; external surface variously striated and marked by numerous concentric lines of growth, sometimes projecting in the shape of pectinated lamellar expansions; shell structure impunctate; hinge line straight, not quite so long as the width of the shell; area double, larger in the dental valve, straight, or bent back at right angles to the valves; the fissure in both is entirely covered by a convex deltidium, which in the larger valve of a few species is perforated near its extremity by a circular foramen; the valves articulate by means of teeth and sockets. In the interior of the dental or ventral valve the muscular impressions occupy an area bordered by the raised edges of the dental lamellæ, and divided by a short mesial ridge. In the interior of the socket or dorsal valve a longitudinal median ridge occurs, and the adductors, in the shape of two pairs of transversely oval scars, are placed one above the other on each side of this ridge.

Strophomena. Blainville, 1825.—Animal unknown; shell depressed, expanded, semicircular, subquadrate, transverse, or elongated; external surface smooth, variously striated or costated. Hinge line straight, generally as long as the width of the shell; dental or ventral valve convex or concave; socket or dorsal valve following the curve of the other, the margin in some species being suddenly and abruptly bent down when the shell is half grown; area double, crenulated at its inner edges, and more developed in the dental valve; fissure in large or ventral valve partly covered by a deltidium, the extremity of the beak entire or perforated by a small circular aperture, which became closed at a more advanced period of the animal's life. In the socket valve the fissure is either partially covered by a deltidium or entirely occupied by a projecting cardinal boss. In the interior of the dental valve, two widely diverging teeth articulate with corresponding sockets in the other valve; the muscular impressions are more or less distinctly margined by a semicircular ridge continued from the base of the teeth, and curving on either side so as to produce a saucer-shaped depression of variable dimensions. The cardinal muscles fix on either side the anterior portion of this cavity; the pedicle muscles leave no definite scars, unless the external portions of the 'cardinal muscular impressions' are due to them. The adductor lies close to a slightly elevated mesial ridge. In the interior of the smaller valve the cardinal process or boss is large, and divided into two pairs of adductor scars, which are frequently bordered by prominent ridges; the vascular impressions consist of large primary vessels which run at once direct to the margin, following a somewhat radiate arrangement, or else the lateral trunks are greatly enlarged and reflected to surround the ovarian spaces.

Streptorhynchus (King, 1850), is a sub-genus, the members of which have the shell of a semicircular convex or concavo-convex shape, and the exterior surface striated and interstriated. The ventral valve has a twisted or bent beak.

Leptæna. Dalman (in part), 1827.—Animal unknown; shell involute, semicircular, transverse, or elongated; surface smooth or variously striated; dental or ventral valve (always ?) regularly convex; socket valve concave and following the curve of the other; area double, fissure in the dental valve partly covered by a deltidium; summit sometimes perforated by a small circular aperture; valves articulating by means of teeth and sockets; in the interior of the dorsal valve the socket ridges are largely developed, the cardinal process or boss small, multifid, and connate with their bases; the muscular impressions left by the adductor are large, produced and elongated, occupying more than two-thirds of the length of the valve, and bordered by well defined ridges. In the interior of the dental valve the muscular scars are small and not distinctly margined; the adductor lies close to a slight mesial ridge, while the cardinal muscles leave larger scars on either side; vascular impressions radiating.

Sub-family ? Davidsonidæ.

Animal unknown; shell fixed to marine bottoms (rocks, shells, and corals) by a portion of the dental or ventral valve; hinge line straight, with a more or less developed false area and deltidium in the attached valve; no calcified supports for the arms, which were evidently fleshy and spirally coiled.

Davidsonia. Bouchard, 1849.—Shell transversely oval, with thick unequal valves, fixed to marine bodies by a portion of the surface of the ventral valve filling outward irregularities, but not reproducing the same internally; the unattached portion of the dental valve rises abruptly, especially in front; area more or less defined, and divided by a convex triangular pseudo-deltidium, considerably notched at its inner margin; upper or socket valve thick, slightly convex or concave; external surface smooth, and marked by concentric lines of growth which extend uninterruptedly over the rudimentary area. Valves articulating by means of strong teeth placed on either side at the base of the fissure, close to the hinge line, and corresponding with sockets in the upper valve. In the interior of the attached valve a hollow is visible under the pseudo-deltidium, affording space for the cardinal muscular process of the other valve; between and below the dental projections are situated the muscular scars, which extend to about a third of the length of the shell; these consist of two deep oval impressions left by the cardinal muscles, and divided by a broad, flattened, and sinuated mesial elevation, to which the adductor was possibly affixed; the greater portion of the interior is occupied by two conical elevations projecting more or less beyond the level of the valve; the lateral and frontal portions of these solid cones exhibit five or six semicircular or spiral projecting ridges, diminishing in surface and width as they approach the summit of the cone, but not distinctly extending over the portion facing the cardinal edge, which is covered to its extremity with the same minute indentures or punctures which are seen on those portions of the internal surface unoccupied by muscular scars; the cones are separated by a longitudinal furrow or space, which blends with the raised border surrounding the interior of the valve. In the interior of the upper or dorsal valve, between the largely developed socket walls and close to the hinge line, is situated a small cardinal process, under this the deep adductor impressions are seen lying in a semicircular depression; in the anterior half of the thickened valve are excavated two conical hollows which correspond to the cones of the attached valves, and like them are separated by a rounded mesial ridge, united near the front to the raised border which surrounds the valve.

Family VII. Productidæ.

Animal unknown; shell entirely free, or attached to marine bottoms by the substance of the beak; valves either regularly articulated or kept in place by muscular action; no calcified supports for the oral appendages, which were no doubt fleshy and spirally rolled.

Chonetes. Fischer, 1837.—Shell inequivalve, compressed, transversely semicircular, with a straight hinge line, commonly as long as the width of the shell, or prolonged in the shape of auricular expansions; dental valve convex, depressed towards the cardinal edge; socket valve always concave, following the curves of the other; area distinct, almost equal in both valves, or larger and more produced in the dental one: the upper edge of the area in the larger valve is acute, and provided with a row of delicate spinose hollow tubes, varying in number in different species, and becoming gradually longer as they recede from the extremity of the beak, diverging obliquely from the hinge line; fissure covered by a pseudo-deltidium. In the socket valve the opening is entirely filled up by a projecting bifid or trifid cardinal process: surface ornamented with minute, longitudinal, dichotomised, or intercalated striæ, rarely largely plaited, but transversely marked by concentric lines of growth. Internally the valves articulate by means of teeth placed at the sides of the fissure of the dental valve, and corresponding sockets excavated on each side of the cardinal prominence already described. In the dental valve a small longitudinal ridge divides the muscular impressions situated on either side; the cardinal muscles probably occupied the greatest space, the adductor lying on either side close to the mesial ridge. In the socket valve a blunt medio-longitudinal ridge divides the quadruple impressions of the adductor muscle, which forms on either side two oval scars, from between which (in some specimens) two short vascular impressions proceed in an outward oblique direction, when turning backwards and inwards they terminate at some distance from their origin. The interior of the valves is covered with minute granulous asperities, arranged in longitudinal lines; animal unknown, probably free, or attached in the young by fibres issuing from the fissure.

Strophalosia. King, 1844.—Shell variable in shape, more or less circular, transverse or elongated, larger or dental valve convex, smaller one concave and following the curves of the other; surface ornamented by scattered tubular spines: beak often irregular, having been affixed by its substance to submarine objects; a small well defined area in both valves, divided by a pseudo-deltidium: hinge line straight; valves articulated by teeth and sockets, the former situated on each side of the base of the deltidium of the larger valve, and the latter on both sides of a cardinal muscular process of the socket valve. Internally a longitudinally raised ridge extends from the cardinal process to about half the length of the valve, on either side of which is seen a small ovate raised muscular scar; the reniform impressions are rather large, their prominent outer edges issue from between the adductor scars, gradually arch forwards and outwards on each side, then turn backwards for about half their length, and finally run inwards horizontally to meet each other near the extremity of the mesial septum.

Aulosteges. Helmersen, 1847.—Animal unknown; shell of an irregular pentagonal shape, with its larger or ventral valve by far the most convex; beak produced, generally twisted either to the one or the other side, and furnished with a well-defined triangular area, longitudinally interrupted by a pseudo-deltidium not quite reaching to the hinge line, which is straight and not provided with articulating teeth; smaller or dorsal valve slightly convex at the umbo, depressed or concave laterally; cardinal edge more or less developed; surface of valves ornamented by a multitude of short tubular spines. In the interior of smaller valve a large and produced trifid cardinal process extends under a portion of the beak and deltidium, filling up the uncovered portion of the fissure, and serving as a point of attachment to the cardinal muscle; under this process a longitudinal mesial ridge extends nearly to the margin, and on either side are placed the elongated ramified adductor scars; the reniform impressions, after dividing the above-named muscle, extend by an outward oblique curve to near the margin, turn abruptly backwards and inwards, and terminate at some distance from their origin. Under the adductor, more towards the centre of the valve, exist two elevations (perhaps brachial eminences).

Productus. Sowerby, 1814.—Shell variable in shape, equivalve, transverse, or elongated, furnished with lateral auricular expansions; large or ventral valve regularly convex, geniculated, or perpendicularly incurved; hinge line straight, commonly shorter than the width of the shell; area very narrow, or no true area, but the cardinal edge considerably thickened; beak incurved. Smaller or dorsal valve concave, following the curves of the other valve. Exterior variously costated or striated, sometimes decussated by concentric lines of growth; from the striæ arise innumerable small closely packed tubular spines, especially abundant on the auricular expansions; in other species they are few in number, large, strong, and irregularly scattered over the surface, or arranged in regular or irregular rows near the cardinal edge; valves unarticulated, probably kept in place by the fibrous membranes and powerful muscular system of the animal. In the interior of the larger valve a narrow mesial ridge separates the two elongated ramified muscular scars left by the adductors (?) (hepatic impressions of

V. Buch); immediately under, but outside these, are seen other two very deep longitudinally striated, subquadrate impressions, probably formed by the cardinal muscles, and more or less widely separated by a mesial elevation or crest; and lower down, more towards the centre of the shell, two other deep concave superficial depressions are visible: the remaining inner surface of the larger valve not occupied by the muscular scars is indented by a multitude of small depressions, increasing in number under the auricles ; in the centre of the hinge line of the smaller valve a prominent trifid cardinal process afforded attachment to the cardinal muscles, under this a narrow longitudinal ridge extends to more than half the length of the valve, becoming more elevated towards its extremity ; on either side are seen the ramified scars left by the adductors, and corresponding to those situated in a similar position in the other valve ; each scar is double, the two portions being separated by the commencement of the great vascular trunks. Outside and in front of the muscular scars, are two elongated or reniform impressions ; their surface is smooth, and they are bounded by ridges, which, after dividing the adductors, proceed in an outward oblique, or almost horizontal direction, when, turning abruptly backwards, they terminate at a short distance from their origin ; between the vascular impressions, and close to the muscular scars, exist two prominences, one on each side of the cardinal ridge ; the internal surface of the smaller valve is covered with innumerable produced tubercles, protruding often in the shape of short spines, especially visible near the marginal portions of the shell ; no calcified supports for the arms, which were probably small and vertically coiled.

Family VIII.—CRANIADÆ.

Animal fixed to marine bottoms by the substance of its lower or ventral valve ; arms fleshy, and spirally coiled ; no hinge or articulating processes ; upper or dorsal valve patelliform.

Crania. Retzius, 1781.—Shell variable in shape, inequivalve, circular, subquadrate, transverse, or elongated ; partially or extensively attached by the substance of its lower or ventral valve ; rarely free ; upper or dorsal valve more or less conical, vertex subcentral ; no articulated hinge or ligament, the valves being kept in place by the action of four muscles, which pass in a somewhat oblique manner from one valve to the other; the attached or ventral valve is generally the thickest, with or without a straight more or less produced beak and false area. External surface smooth, spiny, or variously ornamented by radiating costæ or foliaceous expansions ; the concentric lines of growth passing uninterruptedly over the valves and area ; structure calcareous and tubular. In the interior four principal scars, formed by the adductor muscles, are observable. The anterior pair are approximate, and placed close to the centre, behind which a prominence is sometimes visible in the ventral valve. The posterior pair are situate near the cardinal edge, and are widely separated. The muscular impressions of the attached valve are sometimes slightly convex, at others deeply excavated; those of the dorsal valve are convex, the centre pair sometimes developing very prominent apophyses. The interior of the attached valve is surrounded by a raised and thickened border, exhibiting the tubular shell structure in a conspicuous manner. The disk of each valve exhibits more or less distinct impressions of the vascular system, which is simply digitated.

Family IX.—DISCINIDÆ.

Animal attached by means of a muscular peduncle, passing through the ventral or lower valve, a slit in the hinder portion, or a circular foramen excavated in the substance of the same valve. Arms fleshy ; valves unarticulated.

Discina. Lamarck, 1819.—Shell circular, transversely or longitudinally oval ; upper or dorsal valve conical, patelliform, with the apex inclining towards the posterior margin ; lower or ventral valve opercular, flat or partly convex, and perforated by a narrow oval longitudinal slit, reaching to near the posterior margin, and placed in the middle of an oval depressed disk. Valves unarticulated, being kept in place by four thick adductor muscles, passing rather obliquely from one to the other ; surface smooth, ornamented by numerous striæ radiating from the apex to the margin, or by concentric lines of growth, produced in the shape of foliaceous expansions ; shell structure, horny, and perforated by minute tubuli. In the interior of the perforated valve the muscular disk is more or less prominent, and from the anterior extremity of the fissure a short longitudinal process arises. Four pairs of muscular impressions are visible on the disk ; the posterior submarginal pair are probably those of the sliding muscles ; the central four are the adductor scars, of which two lie on either side of the foramen, while the anterior pair are situated more towards the centre of the shell ; the fourth pair lie external to these. In the upper valve the posterior adductor scars are placed nearly horizontally, at a short distance from the margin, and are much smaller than the anterior pair, which lie obliquely near the centre of the valve ; there are no projecting processes in the interior of this valve.

Orbiculoidea. D'Orbigny, 1847. — Shell orbicular ; patelliform, longitudinally or transversely oval. Upper valve conical with the vertex close to or removed from the posterior margin ; lower valve conical or concave ; no pedicle disk ; *?* a narrow oval or circular aperture, more or less confined in its shape, is situated in a furrow or depression.

Trematis. Sharpe, 1847.—Animal unknown: shell somewhat depressed, suborbicular or transversely oval ; both valves slightly and unequally convex, giving a lenticular form to the shell ; umbo of the upper or imperforated valve submarginal, slightly projecting. Lower or ventral valve with a subcentral umbo, behind which a narrow oblong oval slit reaches to near the posterior margin, and afforded passage to the pedicle fibres of attachment. Internal dispositions unknown ; a wide cardinal margin is visible in the imperforated valve.

Siphonotreta. De Verneuil, 1845.—Animal unknown. Shell oblong, oval, inequivalve ; valves unarticulated ; larger or ventral valve most convex with a straight, thick, perforated conical beak, more or less removed from the hinge line ; foramen circular or elongated, opening on the back of the beak, and communicating with the interior of the shell by a cylindrical tube or siphon, destined to afford passage to the muscle of attachment ; no area or deltidium ; each valve has a wide, crescent-shaped cardinal edge, covered by numerous horizontal lines of growth. Smaller valve slightly convex and depressed, the hinge line forming an arch which merges imperceptibly into the lateral margins. Shell calcareo-corneous, with a distinctly punctured structure and arranged in tubular layers ; surface smooth, but presenting numerous lines of growth, and scattered or closely packed slender, hollow spines, dilated at their base, and somewhat quincuncially arranged ; no calcified supports for the arms. Muscular impressions unknown.

Acrotreta ? Kutorga, 1848.—Animal unknown ; shell triangular, larger valve conical ; false area flat, and bent back at right angles to the margin of the valve, longitudinally grooved along the centre and perforated at its extremity by a small circular aperture ; the lines of growth encircle the shell and pass uninterruptedly over the false area ; the smaller valve is almost flat and operculiform, smooth, and marked by concentric lines of growth. Valves unarticulated ?

Family X.—LINGULIDÆ.

Animal fixed by a muscular peduncle passing out between the beaks of the valves ; arms fleshy, unsupported by calcified processes. Shell unarticulated and subequivalve ; texture horny.

Lingula, Bruguière, 1789.—Shell thin, subequivalve, equilateral, more or less elongated, oval or subpentagonal, tapering at the beaks, widened at the pallial region ; valves unarticulated, held together by the adductor muscles ; both slightly convex, but depressed, beak of the ventral valve more pointed and rather exceeding the other in length ; surface smooth, or concentrically striated, and covered by an epidermis. Animal attached to submarine bottoms by means of a long peduncle passing out between the beaks of the two valves ; no calcified supports ; on each side of the mouth is situated an elongated subspiral arm, fringed exteriorly with numerous cirrhi. In the interior several muscular impressions are visible ; close to the beak are the conjoined depressions left by the pedicle muscle, under these, and laterally near the margin of the shell, exist two large impressions due to the decussating adjustor muscle, and towards the centre are situated two small oblique oval scars, caused by the posterior pairs of adductor muscles, which in the larger valve are divided by a blunt rounded projection, and in the smaller by an elongated mesial elevated crest ; under the last described impressions another triangular depression was occupied by the combined extremities of the anterior pair ; shell almost entirely composed of laminæ of horny matter perforated by minute tubuli.

Lingulella, Salter.—Shell nearly equivalve, broad, oblong, the ventral valve pointed and with a distinct pedicle groove. Muscular scar strong, nearly as in *Obolus*, but the pair of anterior occlusors are more linear, and the adjustors are small and not so outwardly placed as in *Obolus.* The form, as well as what is known of the interior, is more like *Lingula* than *Obolus*, but the arrangement of the muscles is more like that of *Obolus*. The anterior occlusors diverge widely and are linear; the central adjustors come nearly down to them, and the external adjustors are smaller and nearer the centre than those of *Obolus*.

	Cambrian.	Silurian.	Devonian.	Carboniferous.	Permian.	Triassic.	Jurassic.	Cretaceous.	Tertiary.	Recent.
Lingulella . .	1	3	—	—	—	—	—	—	—	—
Obolella . . .	?	4	—	—	—	—	—	—	—	—
Discina . . .	?	10	1	2	1	—	7	?	1	*
Orthis . . .	—	46	5	4	—	—	2	2	2	*
Lingula . . .	—	21	1	6	1	—	—	—	—	—
Kutorgina . . .	—	1	—	—	—	—	—	—	—	—
Obolus . . .	—	2	—	—	—	—	—	—	—	—
Siphinotreta . .	—	2	—	—	—	—	—	—	—	—
Leptæna . . .	—	13	3	—	—	—	—	—	—	—
Strophomena . .	—	21	1	1	—	—	—	—	—	—
Acrotreta. . .	—	1	—	—	—	—	—	—	—	—
Crania . . .	—	7	—	3	1	—	7	4	—	*
Orthisina . .	—	2	—	—	—	—	—	—	—	—
Atrypa . . .	—	7	5	—	—	—	—	—	—	—
Meristella . .	—	9	—	—	—	—	—	—	—	—
Rhynchonella . .	—	18	15	14	—	—	37	17	1	*
Spirifera . .	—	7	19	27	2	—	8	—	—	—
Pentamerus . .	—	7	2	—	—	—	—	—	—	—
Stricklandinia .	—	2	—	—	—	—	—	—	—	—
Porambonites . .	—	2	—	—	—	—	—	—	—	—
Chonetes . .	—	3	2	7	?	—	—	—	—	—
Athyris . . .	—	3	8	9	1	—	—	—	—	—
Retzia . . .	—	2	1	3	—	—	—	—	—	—
Orbiculoidea . .	—	2	—	—	—	—	—	—	—	—
Nucleospira . .	—	1	—	—	—	—	—	—	—	—
Streptorhynchus .	—	—	6	4	1	—	—	—	—	—
Spiriferina . .	—	—	2	4	2	—	3	—	—	—
Cyrtia . . .	—	—	4	2	—	—	—	—	—	—
Terebratula . .	—	—	4	3	1	—	44	23	2	*
Merista . . .	—	—	1	—	—	—	—	—	—	—
Uncites . . .	—	—	1	—	—	—	—	—	—	—
Camaraphoria . .	—	—	1	5	3	—	—	—	—	—
Davidsonia . .	—	—	1	—	—	—	—	—	—	—
Productus . . .	—	—	4	41	2	—	—	—	—	—
Stringocephalus .	—	—	1	—	—	—	—	—	—	—
Rensselaeria . .	—	—	1	—	—	—	—	—	—	—
Strophalosia . .	—	—	1	—	2	—	—	—	—	—
Thecidium . . .	—	—	—	—	—	—	14	1	—	*
Zellania . . .	—	—	—	—	—	—	6	—	—	—
Argiope . . .	—	—	—	—	—	—	3	2	1	*
Terebratulina . .	—	—	—	—	—	—	2	3	2	*
Waldheimia . .	—	—	—	—	—	—	1	8	—	*
Terebratella . .	—	—	—	—	—	—	3	4	—	*
Megerlia . . .	—	—	—	—	—	—	—	1	—	—
Terebrirostra . .	—	—	—	—	—	—	—	1	—	—
Trigonosemus . .	—	—	—	—	—	—	—	2	—	—
Magas . . .	—	—	—	—	—	—	—	1	—	—

Obolus, Eichwald, 1829.—Animal unknown. Shell subequivalve, orbicular, equilateral, slightly transverse or elongated, depressed; valves unarticulated, being held together by muscular action. The larger valve (ventral of Owen) is most convex, with a short obtuse or pointed beak, and wide flattened cardinal edge of false area, over which the semicircular concentric lines of growth of the surface pass uninterruptedly; the flattened cardinal edge is longitudinally grooved by a semi-cylindrical furrow, destined to afford room for the passage of the muscular fibres of attachment; smaller valve rather shorter than the other, slightly convex or almost flat, without any prominent beak or vertex, the hinge line forming a regular arch, and passing imperceptibly into the lateral margins; the cardinal edge is likewise flattened and horizontally striated, but not interrupted by a mesial furrow; external surface smooth or irregularly sculptured by minute undulating wrinkles. Structure calcareo-corneous. In the interior of the larger valve, a narrow slightly elevated longitudinal ridge extends to about half the length of the valve, and four small oval muscular impressions are situated on each side near the cardinal angles, and the other two towards the centre of the valve, a little beyond the base of the mesial ridge.

Obolella, Billings.—Shell ovate, circular, or subquadrate, convex or plano-convex. Ventral valve with a false area which is sometimes minute and usually grooved for the passage of the peduncle. Dorsal valve either with or without an area. Muscular impressions in the ventral valve four, one pair in front of the beak near the middle or in the upper half of the shell, and the others situated one on each side near the cardinal edge. Shell calcareous; surface concentrically striated, sometimes with thin, expanded, lamellose ridges. The shells resemble those of *Obolus*, but the muscular scars are arranged differently. In *Obolus* the central scars have the smaller extremities directed downwards and converging towards each other, but in *Obolella* the arrangement is just the reverse.

We do not propose to enter into details respecting the geological distribution of this class in Great Britain, since these will be given more or less fully in the geological articles; but as a summary of what is known we give the annexed table, drawn up by Mr. Lobley. ('The Geological Magazine,' vol. v. p. 498.) The genera are arranged in the order in which they first appear; the figures indicate the number of species recorded from each geological group; and the asterisks denote that the genus is represented by living species.

BREAM [E. C. vol. i. cols. 666-667]. There are three species of the genus *Abramis* which abound in most of the rivers of the European continent, viz., *A. brama; A. vimba;* and *A. blicca.* All of them extend far to the north, being recorded as natives of Finland by Dr. Malmgren. *A. vimba* is one of the commonest fishes in the March, Theiss, and other rivers of the great Hungarian plain. The genus is of considerable interest on account of the reported native hybrids which have recently been discovered. Siebold has recognised five hybrid forms amongst the fresh-water fishes of central Europe; in two of these one of the parent forms is an *Abramis*. These two hybrids have received various names; but Jaeckel calls them *Bliccopsis abramo-rutilus,* believed to be a hybrid between *Abramis blicca* and *Leuciscus rutilus;* and *Bliccopsis erythrophthalmoides,* a hybrid between *Abramis blicca* and *Scardinius erythrophthalmus.* The *Abramis Buggenhagii*, or Pomeranian bream, is also considered to be a hybrid by some ichthyologists. The fact that in these as well as all the other cases of hybridism amongst fishes, the parents belong not only to different species, but even to different genera, is remarkable. Are these really cases of hybridism? If so, are the parents really generically distinct? and if the first or both the questions are affirmatively established, is it consistent with the prevailing rules of nomenclature to distinguish hybrids by generic names?

C

CAMBRIAN GROUP [E. C. vol. i. cols. 727-728]. Geologists still differ from one another as to the rocks which they assign to this group. In this article we shall divide it into two portions, viz., the Lower Cambrian, comprising the Llanberis Slates and Harlech Grits; and the Upper Cambrian, comprising the Lingula Flags, and the Tremadoc Slates. By many geologists the term is restricted to what are here called Lower Cambrian, while the beds above are assigned to the Lower Silurian.

The Lower Cambrian is developed to a greater or less extent in Shropshire, North Wales, Scotland, Ireland, France, Bohemia, North America, and probably Australia; and in all these countries is mainly composed of inconstant alternations of grits, shales or slates, and conglomerates. There are large tracts in various parts of the world where these rocks appear to be entirely absent, and in them we find Silurian strata sometimes with, sometimes without, an intervening conglomerate, resting unconformably upon the subjacent Huronian or Laurentian formations. These latter conglomerates are readily distinguished from those of the Cambrian group, inasmuch as they are always derived mainly or wholly from the rocks on which they rest, while the Cambrian conglomerates have little or no such lithological resemblance. So far as geologists have surveyed it would seem that the area occupied by these Lower Cambrian coarse sandstones and shales is far smaller than that occupied by rocks of a newer age resting upon those of the Laurentian formation. The conclusion to be drawn is that the Lower Cambrians are local, and not universal. But not only are they restricted to certain areas, but the order of their accumulation in one area differs from what it is in others, even when they are close together. They are not much altered by metamorphism, and plutonic rocks are by no means abundant. Limestones are remarkably scarce ; indeed, they may be said to be absent, for all the calcareous matter known in these beds consists of a few thin veins in Wales, and a narrow strip in Brittany. Phosphates, sulphates, and graphite also are seldom met with. In nearly all these points the Lower Cambrian differs from the Huronian. The latter consists largely of plutonic rocks, such as diorite or greenstone ; and of metamorphic rocks, such as gneiss and mica schist ; it contains several thick bands of limestone, some of which are darkly coloured, probably by graphite. There is also an important difference in their stratigraphical arrangement. The Lower Cambrian passes conformably into the Lingula Flags, but when these latter rocks rest upon the Huronian there is always a break. On these grounds it is thought the Lower Cambrian is a newer formation than the Huronian. No fossils have been found in the Huronian ; and but a few in the Lower Cambrian, viz., *Arenicolites didymus*, *A. sparsa* ; *Histioderma Hibernica* ; and *Houghtonia pœcila*, annelids ; *Palæopyge Ramsayi*, a Trilobite ; *Oldhamia antiqua*, and *radiata*, sea-weeds according to Goeppert, and zoophytes according to other authorities ; and *Chondrites*, a sea-weed in the opinion of some persons, but more probably the track left by burrowing crustaceans. The annelids are represented by peculiar impressions resembling surface holes and burrows on the finer grained sandstones and shales. They are not unlike similar marks formed by the common Lob worm (*Arenicola*) on modern sands. These shales are also marked with what are considered to be wave marks, rain drop impressions, and sun cracks. The locality which has yielded the Cambrian fossils most abundantly is Bray Head, in Wicklow, and the neighbourhood. *Oldhamia antiqua* is most frequently met with in the shales, and more particularly in those of a red or green colour at Bray ; of a brown or purple colour at Carrick mountain in Wicklow ; and in the brown laminated shales of Howth peninsula, Dublin County. It is less abundant than *O. radiata*, does not occur in such dense masses as that species, and seldom in the same bed. *O. radiata* occurs at Bray Head, and at Greystones, but not at Howth or Carrick mountain. In some of the greenish grits overlying the Oldhamia beds of Bray Head, some tubular burrows have been found by Dr. Kinahan, which he says belong to a "tentacled sea worm, evidently cephalo-branchiate, and not very dissimilar from the common Lug-worm (*Arenicola*) of our present seas."

In the character of many of the fossils, as well as of the strata in which they are entombed, the proximity of land is clearly indicated. The presence of these features singly would not perhaps prove much, but occurring as they do in conjunction, one lends support to the other, and thus increases the weight of the evidence. The wave marks, so called, by themselves tell us nothing more than that the particles of the sandstone or shale were at one time sufficiently mobile to respond to the undulating motion of some fluid (which may have been deep water, shallow water, or air,) passing over them. The holes may have been formed in deep water, or they may not; and in either case they do not necessarily imply a contiguous shore. The rain drops may have been burst gas bubbles. But when we find the holes are usually situated on the sheltered side of the ripples, our suppositions lose much of their force ; for there are few localities which burrowing worms more delight to frequent than the reaches of sand or mud exposed between tide marks, and nowhere do their holes abound more than in the places where the water collects, which is usually at the junction of the steep slope of one ripple with the shallow slope of the next. The presence of sun cracks implies an air-dried surface, but such surface might have been a sandbank in the middle of the ocean. The nature of some of the strata, however, not only indicates a neighbouring land, but furnishes a clue where some of it was situated. Thus, in North Wales and South Scotland, the lowest Cambrians are sandstones and schists ; they are of a similar nature in the South of Ireland ; but in the North of Scotland they consist of sandstones, grits, and conglomerates : the conglomerates are largely developed, and form a large proportion of many of the highest hills in Sutherlandshire, which were formerly considered to be composed of Old Red Sandstone. They are of such an enormous thickness that they must represent the result of a very prolonged contest between the sea and land. They have been since then carved into eminences which form one of the most striking features in the scenery of the Scottish Highlands. They are excellent examples of the power of denudation, and if one feels awe at being looked down upon by the forty centuries of the Egyptian pyramids, how much must he feel humbled in the presence of these natural pyramids, which were constructed innumerable centuries ago. Their picturesque appearance may be partially conceived from Hugh Miller's graphic description of them :—"Rising over a basement of rugged gneiss hills, that present the appearance of a dark tumbling sea, we descry a line of stupendous pyramids, from 2000 to 3000 feet in height, which, though several miles distant in the background, dwarf, by their great size, the nearer eminences into the mere protuberances of an uneven plain. Their mural character has the effect of adding to their apparent magnitude. Almost devoid of vegetation, we see them barred by the lines of the nearly horizontal strata, as edifices of man's creation are barred by their courses of dressed stone ; and while some of their number, such as the peaked hill of Suilvein, rise at an angle at least as steep, and nearly as regular, as that of an Egyptian pyramid, in height and bulk they surpass the highest Egyptian pyramid many times. Their colour, too, lends to the illusion. Of a deep red hue, which in the light of the setting sun, brightens into a glowing purple, they contrast as strongly with the cold grey tone of the gneiss track beneath, as a warm coloured building contrasts with the earth-tinted street or roadway over which it rises." In Norway also the lowest Cambrians consist largely of conglomerates ; so that it is clear there was land at this time somewhere near the extreme north-west of Europe.

The Upper Cambrians are far more abundant in organic remains ; and, therefore, each of its divisions will be noticed separately. The oldest of the two consists of the Lingula flags, which have been found in both North and South Wales. Their thickness is very great, being about 6000 feet in Merionethshire : 2000 feet farther north near Llanberis ; and entirely absent still farther north in Anglesea, and on the Menai Straits. Farther south, at St. David's, in Pembrokeshire, these rocks are well displayed, and the succession, according to Mr. Salter, is as follows :—Resting upon a considerable thickness of red and purple grits, intermixed with some sandstones, which are assigned to the Lower Cambrian, there is a thick mass of black shales. These represent the *Lower Lingula flags*. The shales are very uniform in their upper part, but contain much sandstone in the lower portions. They appear as though they had been deposited in deep water. The fauna comprises—*Olenus catarractes*, common ; *O. gibbosus*, less common ; *Agnostus*, common ; *Paradoxides Davidis*, common ; *P. aurora* and *P. Hicksii*, less common ; *Lingulella*, and *Anopolenus Henrici*, rare ; *Holocephalina*, *Microdiscus punctatus*, *Leperditia Solvensis*, *Theca corrugata*, and *Protospongia fenestrata*. Above these come the *Middle Lingula flags*, which consist of a thick series of hard light coloured sandstones with ripple markings, worm-tracks, and burrows, and other indications of shallow water. Here *Lingulella Davisii* and *Hymenocaris* are the common fossils ; while *Olenus* is rare. While the uppermost of all are the *Upper Lingula flags*, which resemble the lower flags in being composed of fine black shales. This series, however, is thin, not exceeding 300 feet in thickness. The shales are crowded with minute crustaceans, although shells are rare ; and appear to have been deposited in deep water. Here again *Olenus* and *Agnostus* are common ; but they are represented by species different from those in the Lower Lingula flags, and are accompanied by *Conocephalus*, *Dikelocephalus*, and several species of *Orthis*. In addition to these there are several species mentioned in the Catalogue of the Fossils in the Museum of Practical Geology, Jermyn-street, London, as belonging to the Lingula flags, but without indicating to what part of the series they belong. Altogether, the number of species found in these rocks in Great Britain exceeds 70.

The following classified list will indicate its general character. It is drawn up from Sir R. I. Murchison's 'Siluria,' and the several papers quoted at the end of the article :—

Plantæ. None.

Protozoa.
Amorphozoa. 1 genus; 3 species.
Protospongia diffusa.
P. fenestrata.
P. flabella.

Cœlenterata.
Actinozoa. None.
Hydrozoa. 1 genus; Buthotrephis.

- Annulosa.
    - Echinodermata. 1 genus; Protocystites.
    - Annelida. 3 genera; 4 species.
        - Cruziana semiplicata.
        - Scolecoderma antiquissima.
        - S. tuberculata.
        - Serpulites fistula.
    - Crustacea. 17 genera; 49 species.
        - Agnostus Davidis.
        - A. princeps.
        - A. scutalis.
        - A. trisectus.
        - A. pisiformis.
        - A. nodosus.
        - A. obtusus.
        - Anopolenus Henrici.
        - A. Salteri.
        - Calymene obtusa.
        - Conocoryphe abdita.
        - C. applanata.
        - C. bufo.
        - C. depressa.
        - C. humerosa.
        - C. invita.
        - C. simplex.
        - C. variolaris.
        - C. micrura.
        - C. Williamsonii.
        - C. longispina.
        - C. bucephala.
        - Cytheropsis.
        - Dikelocephalus celticus.
        - D. discoidalis.
        - Erynnys venulosa.
        - Holocephalina primordialis.
        - Hymenocaris vermicauda.
        - Illænus Murchisoni.
        - Leperditia punctatissima.
        - L. solvensis.
        - Microdiscus punctatus.
        - Olenus alatus.
        - O. catarractes.
        - O. flagellifer.
        - O. humilis.
        - O. micrurus.
        - O. pecten.
        - O. scarabæoides.
        - O. serratus.
        - O. gibbosus.
        - O. truncatus.
        - Parabolina spinulosa.
        - Paradoxides aurora.
        - P. Davidis.
        - P. Hicksii.
        - Peltura scarabæoides.
        - Sphærophthalmus bisulcatus.
        - S. humilis.
- Mollusca.
    - Polyzoa. 2 genera; 2 species.
        - Diastopora (?) consimilis.
        - Dictyonema sociale.
    - Brachiopoda. 6 genera; 13 species.
        - Discina labiosa.
        - Kutorgina cingulata.
        - Lingula pygmæa.
        - L. squamosa.
        - Lingulella Davisii.
        - L. lepis.
        - L. ferruginea.
        - Obolella Betti.
        - O. maculata.
        - O. sagittalis.
        - Orthis flabellulus.
        - O. lenticularis.
        - O. Hicksii.
    - Lamellibranchiata.
    - Gasteropoda. } None.
    - Heteropoda.
    - Pteropoda. 3 genera; 5 species.
        - Cyrtotheca hamula.
        - Stenotheca cornuspira.
        - Theca corrugata.
        - T. obtusa.
        - T. penultima.
    - Cephalopoda. None.
- Vertebrata. None.

Altogether there are 34 genera and 78 species; the relationship of which with the Silurian fauna may be seen from the following analysis, which is based upon the tables in Murchison's 'Siluria.'

Of the *Amorphozoa* none pass up. Of the *Annelida*, *Cruziana* and *Scolecoderma* do not pass up; *Serpulites fistula* does not pass up, but four species of the same genus occur in the Llandovery and Wenlock. Of the *Crustacea* 8 genera and 3 species pass up. Thus *Agnostus princeps* passes up into the Llandeilo associated with two other new species; two species occur in the Caradoc; and one in the Ludlow. *Calymene* has 3 species in the Llandeilo, 4 in the Caradoc, and 2 in the Llandovery, which two continue on to the Ludlow. *Conocoryphe* has 3 representatives in the Llandeilo. *Cytheropsis* also occurs in the Caradoc. *Dikelocephalus celticus* passes into the Llandeilo and is associated with a new species. *Illænus* has 1 Llandeilo; 7 Caradoc; 5 Llandovery, and 3 Wenlock species. *Leperditia* has a species which occurs in the Ludlow and Passage beds. *Olenus* has 1 Llandeilo species. Of the *Polyzoa*, one genus and one species passes up, viz., *Diastopora* which is represented by *consimilis* in the Llandeilo, and *irregularis* in the Wenlock. Of the *Brachiopoda* 5 genera and 1 species pass up. *Discina* has 5 Caradoc and 6 Llandeilo species. *Lingula* has 5 Llandeilo, 4 Caradoc, 3 Llandovery, 2 Wenlock, 6 Ludlow, and 1 Passage bed species. *Lingulella lepis* passes up into the Llandeilo. *Obolella* has 1 Llandeilo species. *Orthis* has 13 Llandeilo, 35 Caradoc, 19 Llandovery, 12 Wenlock, and 3 Ludlow species. Of the *Pteropoda* one genus, *Theca*, passes up, having 8 Llandeilo, 1 (?) Caradoc, 2 Wenlock, and 2 Ludlow species.

Of the genera 12, viz., *Agnostus*, *Calymene*, *Conocoryphe*, *Dikelocephalus*, *Illænus*, *Olenus*, *Diastopora*, *Lingula*, *Lingulella*, *Obolella*, *Orthis*, and *Theca* pass into the Llandeilo; 8, viz., *Agnostus*, *Calymene*, *Cytheropsis*, *Illænus*, *Discina*, *Lingula*, *Orthis*, and *Theca* pass into the Caradoc; 5, viz., *Serpulites*, *Calymene*, *Illænus*, *Lingula*, and *Orthis* pass into the Llandovery; 8, viz., *Serpulites*, *Calymene*, *Illænus*, *Diastopora*, *Discina*, *Lingula*, *Orthis*, and *Theca* pass into the Wenlock; 6, viz., *Agnostus*, *Calymene*, *Leperditia*, *Lingula*, *Orthis*, and *Theca* pass into the Ludlow; and 2, viz., *Leperditia* and *Lingula* pass into the Passage beds. Hence it appears 35 per cent. of the genera pass up into the Llandeilo; 23 per cent. into the Caradoc and Wenlock; 17 per cent. into the Llandovery, and about 6 per cent. into the Passage beds. Three species, namely, *Agnostus princeps*, *Dikelocephalus celticus*, and *Lingulella lepis* pass up into the Llandeilo, or about 4 per cent., and one species of *Cytheropsis* is said to pass up into the Caradoc, or rather more than 1 per cent. Hence it appears that the break in life is considerable as regards generic forms; but almost total specifically. It should be borne in mind that in this analysis the term 'Llandeilo' embraces the Tremadoc slates.

The formations which in foreign countries seem to correspond with the Lingula flags of England are the Potsdam sandstone of North America, the *Olenus* beds of Norway and Sweden, the *Olenellus* shales of Vermont, and the schists containing *Paradoxides* at Braintree and in Newfoundland; but in the present state of our knowledge there is great difficulty in correlating the rocks of one country with those of another. The Potsdam sandstone probably underlies all the Silurian and Post-Silurian rocks of North America. It is best seen on the borders of the exposed Laurentian area which lies just to the north of the United States, and dips southerly towards the south, and northerly towards the north. Its thickness is variable, and may be stated to be, on the average, about 300 feet. This estimate, however, is not founded on any precise data; generally speaking it is thickest towards the boundaries of the United States. Thus, near Lake Superior, the thickness is 250 feet, and on the river St. Croix, Wisconsin, it is 700 feet. Farther south, as in Iowa, it is rather more than 100 feet thick, but far away in the south, as in Texas, the thickness appears to have increased to 500 feet. In the eastern parts, as in the region of the Appalachians, its thickness is also very great. Where the sandstone is thickest the structure is more or less laminated, ripple-marked, and conglomerated; apparently indicating that the shallower waters were situated at these parts. It is also noticeable that the fossils are nearly always found associated with these apparent indications of shallow water; and that these occur in the vicinity of what was probably the land of that period, now represented by the Black Hills of Dakotah, the eastern flanks of the Appalachian Mountains, and the Lake district. The structure of the sandstone in the more central of the United States is markedly different from what it is in the parts indicated; this is well shown in Iowa, where it is exposed by fluviatile denudation along the upper Iowa river. In this district it is about 100 feet thick and almost entirely composed of pure silica. The impurities do not exceed ½ per cent., and the great bulk of them consists of oxide of iron. The silica is in the form of nearly spherical grains of the size of a large pin's head, which sometimes show imperfectly developed crystalline facets. These grains are feebly held together by a calcareous, ferruginous cement, so that the sandstone readily crumbles down when rubbed between the fingers. These characters of purity and friability are very prevalent in the sandstone of the Western States, and render it a good material for the glass manufacturer. The most characteristic features of this sandstone in Iowa are its freedom from argillaceous matters, the almost entire absence of conglomerate or pebble bands, the comparative rarity of lines of oblique deposition, lamination, and other signs of shallow water, and the rarity of organic remains. It has been stated that a few seams of clay occur, but these on chemical examination have proved to be purely calcareo-magnesian in their composition. On the borders of the sandstone, where fossils occur, conglomeratic and laminated beds, together with oxide of iron, and carbonates of lime and magnesia, are marked features. These facts seem to indicate that the central portions of the United States cover the area of the central and deeper parts of the sea of the Potsdam epoch.

The fossils are generally similar to, but specifically different from, those of the Lingula flags of Britain; but at present we are not aware that anyone has separated them into groups, as has been done with the British fossils. The characteristic genera are *Archæocyathus*, *Graptolithus*, *Lingula*, *Obolus*, *Obolella*, *Orthisina*, *Theca*, *Ophileta*, *Conocephalus*, *Dikelocephalus*, *Paradoxides*, *Microdiscus*, *Arionellus*, and *Agnostus*.

The Tremadoc slates are composed of dark, earthy slates, 1000 feet thick near Tremadoc in Caernarvonshire. Mr. Salter has divided them into an upper and lower division based upon the palæontological evidence known to him, which was (in 1857) 20 species in the upper division and 15 in the lower. In the lower division occur *Psilocephalus innotatus*, *Conocoryphe depressus*, *Niobe Homfrayi*, *Theca operculata*, *T. arata*, *T. bijugosa*, *Ogygia scutatrix*, *Lingulella lepis;* and in the upper division, *Angelina Sedgwickii*, *Ogygia scutatrix*, *Lingulella Davisii* and *lepis*, *Agnostus princeps*, *Ampyx* (? sp.), *Asaphus Homfrayi*, *A. affinis*, *Cheirurus*, *Conocoryphe venata*, *C. olenoides*, *Olenus Sedgwickii*, *Mytiloides lingulæcomes*, *Conularia Homfrayi*, *Theca simplex*, *T. cuspidata*, *T. arata*, and *Bellerophon arfonensis*.

The lower members of the Taconic system of Emmons and of the Quebec group of the Canadian Surveyors probably correspond with the Upper Cambrian. [QUEBEC GROUP, E. C. S.]

Sir Roderick I. Murchison's views as to the stratigraphical classification and parallelism of the strata here called Upper Cambrian are somewhat different from those indicated above. In the last edition of his 'Siluria' his opinions are expressed in the following table. The beds are separated from the overlying Lower Silurian strata under the term "Primordial." The species and genera mentioned refer to the American area only.

		Characteristic Fossils.
Tremadoc slates.	Lower calciferous sandrock. Upper Potsdam sandstone.	Polyzoa and corals of the genera *Retepora*, *Ptilodictya* (*Stictopora*), *Petraia* (*Streptelasma*) and *Chætetes;* with encrinites; *Leptaena; Orthis; Atrypa; Maclurea magna*, *Scalites; Raphistoma Murchisonia*, *&c.; Illænus; Asaphus* (?); *Isotelus gigas*, *I. canalis.*
Lingula flags.	Lower Potsdam sandstone. St. John's group.	*Ophileta compacta*, *O.* (?) (*Maclurea*) *sordida; Maclurea matutina; Turbo;* and *Pleurotomaria* (?) *Orthoceras*, 2 species; *Lingula prima*, and *antiqua; Scolithus linearis; Cruziana* and seaweeds.

(Bigsby, *Q. J. Geol. Soc.* xix., p. 36; Baily, *Geological Magazine*, Sept., 1865; Hall and Whitney, *Geol. Survey of Iowa*, vol. 1; Lyell, *Elements of Geology*, 6th Ed.; Dana, *Manual of Geology*, 2nd Ed.; Salter and Hicks, in several papers in *Geological Magazine*, vol. iii., and *Q. J. Geol. Soc.*, vols. xix. xx. xxi.; Salter, *Q. J. Geol. Soc.* xxv., and *British Association Reports* for 1865; Plant, *Q. J. Geol. Soc.* xxii.; Murchison, *Siluria*, 4th Ed., &c.)

CARBON [E. C. vol. i. col. 776]. Few elements present so many points of interest as carbon. The sparkling diamond has its charms for the man of wealth and taste; coal and anthracite, our principal magazines of force, are sought after by the manufacturer; and graphite is in daily use by the student and the chemist. The mineralogist and physicist is ever studying the varied forms and properties of carbon; the geologist its stratigraphical and lithological distribution; and the physiological chemist can scarcely carry out any inquiry without concerning himself more or less with this element. Next to oxygen and silicon it is, perhaps, the most abundant of all the elements; it is found, combined or uncombined, in rocks of every age, from the Lower Laurentian to those in actual formation; and yet the evidence we have seems to show that probably all the free carbon formed during this inconceivable length of time owes its existence as such to the organic world. Before, however, entering into any details as to the relations between carbon and the living creation, we would say something as to a few of its general physical properties.

In whatever form it may occur it possesses the constant qualities of solidity and infusibility. The density is variable, and the order of the principal forms, beginning with the lightest, is lamp-black, light wood charcoal, dense wood charcoal, coke, anthracite, graphite, and diamond. On examining the properties of these we should frequently find a gradation in their intensity corresponding, directly or inversely, with their density. Thus lamp-black combines readily with oxygen at a moderate temperature; light charcoal requires a higher temperature; and a further increase of heat is necessary to effect the same result as we pass from the less dense to the more dense, until, in the case of the diamond, the difficulty is to obtain a temperature sufficiently great. The same gradation is met with in their specific heats, that is, the quantity of heat required to raise a given weight by the same number of degrees. If the quantity of heat required for water be called 1, that required for wood charcoal will be ·2415; that for graphite, ·2008 (Regnault), ·174 (Kopp); and that for diamond, ·1468. Other illustrations of a similar kind might be quoted to the same effect; but it must be remembered that in some of their properties this gradation extends to some and not all the forms, as may be exemplified by their power of conducting electricity, which increases with the density up to graphite, but is almost absent in the diamond.

On referring to the action of heat on the various forms of carbon it will be seen that a given weight of carbonic acid may be obtained either by exposing a given weight of charcoal, say 1 lb., to which a certain quantity of heat has been added, to an atmosphere of oxygen; or 1 lb. of diamond, to which a much larger quantity of heat has been added. Since both are equally pure carbon, and the results are the same, the difference between them, whatever it may be, is representable by a certain quantity of heat. What, then, is there in heat that can possibly represent this difference? It would require a long article especially devoted to the point to enable us to give an adequate answer to this question; but we will endeavour to indicate as briefly as possible the substance of what such an answer would be. As a general rule heat expands a body, and in so doing it diminishes the force with which its particles cohere together, so that the greater the cohesive power the larger is the quantity of heat required to counterbalance that power; heat is an expansive or repulsive force, which acts in opposition to cohesive or attractive force. As the relation between heat and mechanical energy is well known, it would not be difficult to construct a table showing the relation between the repulsive and attractive powers at different temperatures. A table of this kind relating to carbon would indicate that in the diamond the cohesive force is far greater than in graphite; in graphite than in charcoal; and so on. If, then, a larger quantity of heat be added to the diamond, its cohesive force is lessened and approximated to that of charcoal. But in addition to the repulsive and attractive forces acting on particles of a similar nature, there are similar forces acting between particles of a dissimilar nature, or rather between particles of different elements. This latter kind of attractive force constitutes what is known as adhesion, solution, and chemical affinity; but at present the last is the only one that concerns us. The chemical affinity between two different elements increases in strength in proportion as the temperature is lowered, provided they are not acted on by other disturbing forces; or, what comes to the same thing, it increases with their density; moreover, it only acts when the particles are brought to within a certain, but very minute, distance of each other. Applying these considerations to carbon and its combination with oxygen, we should say that at ordinary atmospheric temperatures the force binding the particles of the charcoal together is greater than the attractive force between the charcoal and the oxygen; so that no action takes place. By applying heat we diminish the cohesive force of the charcoal, and at a certain temperature reduce it to less than the attractive force between oxygen and carbon. At this point combination takes place, and carbonic acid is formed. As anthracite is chemically identical with charcoal, its greater density implies that its particles are held together by a greater cohesive power; and consequently a greater quantity of heat or repulsive force must be imparted to it to enable the attractive force between anthracite and oxygen to come into play. And for a similar reason diamond requires a still greater amount of heat before it will combine with oxygen. This is a partial explanation stated in its simplest aspect, but an experimental solution of the question would be far more complicated, in consequence of the modifying action of electricity and other physical forces of which no account has been taken. The main conclusion we would draw from these considerations is, that since diamond and graphite require more heat than charcoal to enable them to act upon oxygen, a greater amount of force was expended in forming them. We will next endeavour, then, to ascertain how this force was probably applied.

When carbon is separated from its compounds under the ordinary atmospheric pressure, it almost invariably assumes its least coherent and lightest form, viz., soot or lamp-black. When it is separated from a solution of one of its compounds, and is subjected to pressure at the time of its separation, it generally takes the form of graphite. An example of this kind occurs in iron-smelting. Several tons of the iron are reduced to the fluid state holding carbon in solution; as the mass cools the carbon is liberated, when under a pressure of several tons, in the form of flakes of graphite. A somewhat similar phenomenon occurs during the cooling of some of the liquors used for the manufacture of caustic alkali. Several tons of fluid are acted upon in the same vessel; the carbon is separated by the decomposition of some of its compounds, and rises to the surface of the alkaline fluid. As it gradually collects it forms a dark-looking scum on the surface. If a little of this be collected and washed with water and hydrochloric acid, it is seen to be composed of an extremely fine bright powder. This powder is incombustible when heated by itself in a platinum crucible, and possesses all the properties of graphite. A few grains of charcoal are generally mingled with the graphite, which readily burn when heated; probably these represent the carbon liberated near the surface under slight pressure. We have not the means of saying under what circumstances the diamond is formed, since none of the numerous attempts made to obtain it artificially have succeeded. In the majority of these trials recourse was had to an exceedingly high temperature under light pressure; whereas, in our opinion, the process more calculated to effect the object desired would be high temperature combined with great pressure. The employment of a high temperature for the purpose of compressing a body may appear paradoxical, seeing that heat has a tendency to render bodies less dense and not more dense. This is the case when the bodies are free to expand; but when a light solid is heated in a confined space containing a gas, the tension of the gas is increased, and its particles press with greater force against the solid, provided no chemical action takes place and the gas is not liquefied. Thus, when a light charcoal is subjected to a high temperature in a confined space its density is increased.

In the formation of the natural carbons there is little or no evidence of an intense heat having been brought into operation, but there is, in almost every case, abundant actual or presumptive evidence of their having been subjected to pressure accompanied by a very moderate degree of heat. The geological distribution of the carbons has not been thoroughly studied. It may, however, be here stated that graphite is rarely found in the position in which it was originally deposited, but generally in sedimentary strata under circumstances which show that it has been derived from some older stratum. When it retains the position in which it was first deposited it always occupies part of the oldest series of rocks, such as the Laurentian series of America; and since the oldest rocks are usually those which have, or have had, the greatest thickness of rock above them, they are those which have, or have had, the greatest amount of pressure upon them. Although the evidence as to what this pressure has been is not readily attainable, we believe that its intensity is indicated by the quantity of heat required to diminish the density of the carbon to what it probably was when first deposited, that is, about that of wood charcoal. In the absence of any experimental data upon which to base calculations, we will content ourselves with saying that, judging from density alone, we should estimate the pressure necessary to reduce charcoal to the density of graphite at about 370 atmospheres, or about 5300 pounds on the square inch. In the above remarks we have confined our attention chiefly to density, but it must not be overlooked that the difference between the native carbons cannot be wholly accounted for simply by different degrees of pressure. They are derived from different substances; from different plants; and if from the same plants the proportions in which the species entered into them varied. Further, they have undergone various kinds of treatment; some occur under circumstances which allow of the ready escape of the gases that may be evolved from them; some are so placed that not only are the gases formed hermetically sealed, but their further evolution is checked; in short, so manifold are the conditions, that they can rarely have been precisely the same; and hence it is that two specimens of amorphous native carbon are rarely absolutely similar.

When the properties of the elements are studied it frequently happens that a simple relation is observed between the intensity of the property and the atomic weight. This, for instance, is the case with the specific heat of the solid elements, which, when multiplied by the atomic weight, gives a nearly constant number, viz., about 6·4, but silicon, boron, and carbon are exceptions. Berthelot suggests that it is owing to their density being greater than that of the other elements in proportion to their atomic weight. It is a well ascertained fact that in the same element the specific heat is diminished as the density is increased; and carbon itself furnishes a good illustration of this, charcoal having a far higher specific heat than the diamond. The figures which have been given referring to the specific heat of most of the varieties of carbon are probably somewhat too high owing to the heat developed by the absorption of gases, water, &c., not having been deducted from the general result. This, however, does not affect the statement that the less dense varieties have a higher specific heat than the more dense. Regnault's results were ·261 for animal charcoal, ·241 for wood charcoal, ·209 for gas carbon, ·202 for native graphite, ·197 for iron graphite, and ·146 for the diamond. More recently Kopp has obtained results which are probably more accurate; his figures are ·185 for a very dense gas carbon, ·174 for a graphite from Ceylon, and ·166 for an iron graphite. If, then, silicon, boron, and carbon be denser than the other elements relatively to their atomic weights, we should expect that their specific heats would be less. On comparing the atomic weights, specific gravities, and specific heats of the elements, we find that carbon is relatively the densest of all; then follows boron, and probably glucinum and silicon would come next. The following table will perhaps indicate more clearly what is meant:—

Substance.	at. wt.	sp. gr. H.=1. Water=11,178.	sp. gr. ÷ at. wt.	sp. ht. Water = 1	sp. ht. × at. wt.
Carbon . .	12	39,346	3262	·146	1·76
Boron . . .	10·9	29,398	2770	·25	2·75
Glucinum .	9	23,473	2608	?	?
Silicon . .	28	?		·161	4·50
Copper . .	63·4	99,831	1574	·095	6·0
Antimony .	122	76,681	628	·0073	6·0
Gold . . .	197	216,406	1098	·0047	6·3

The first four on the list are the exceptional elements, while the last three are examples of the normal elements, or those whose atomic heats are about 6·4. We cannot place much reliance upon the more minute details of the table, since the specific gravity adopted is that of the heaviest varieties, and we are ignorant what was the actual specific gravities of the specimens which yielded the specific heats given. For purposes of minute comparison this is an essential point; but it does not so much matter when the comparison is more general. The degree of condensation of gold is about 1100, and its atomic heat 6·3; the condensation of boron is 2770, and its atomic heat 2·75; and the condensation of carbon is 3262, and its atomic heat 1·76. Whether this is only a coincidence or not we do not know; still there is an apparent relation between the degree of condensation and the specific heat. Thus the proportion between 1100, 2770, and 3262 is inversely as the proportion between 6·3, 2·33, and 1·96, which numbers come near the atomic heats given above. Probably there would be a still closer agreement if all the data were derived from the same series of specimens.

Another remarkable property of carbon is its inertness when free, and stability at ordinary temperatures. If we compare it with the elements having an atomic weight near its own we find that most of them are gases, as, for instance, hydrogen, nitrogen, oxygen, and fluorine; while others are so readily oxidized that it is difficult to obtain them in a free unoxidized state, as, for instance, lithium, sodium, magnesium, and potassium. This passiveness, however, only belongs to carbon in its denser states, for if placed under suitable conditions few elements have a greater affinity for each other than carbon and oxygen; and it is probable that were carbon ordinarily as light as lithium, sodium, or potassium, it would be as rarely met with in the free state as any of the metalloids mentioned. This energy of combination is also indicated in the difficulty with which the compound formed by them, carbonic acid, is decomposed.

Every property of carbon seems to act so essential a part in adapting it to the functions which it performs in nature that it appears to be a sign of ignorance when any of its properties are particularly referred to as specially adapting it for those functions. Nevertheless, we would fain dwell somewhat longer upon the powerful attraction between carbon and oxygen under certain conditions, and the absence of any attraction under other conditions, because this phenomenon is a highly important link in the chain of effects and causes which constitute the material mainspring of life.

When coal is burnt in an excess of oxygen it forms carbonic acid with the evolution of intense heat. The quantity of heat thus given out is estimated roughly at 8000 heat units, that is, the combustion of 1 lb. of coal would yield heat sufficient to warm 8000 lbs. of water from 32° to 33° ·8 F., supposing none of the heat to be misapplied; or, stated in another way, it would suffice to raise the temperature of 80 lbs. of water at 32° F. to the boiling point. Since the proportion between carbon and oxygen is as 12 to 16, the weight of the carbonic acid formed by the combustion of 1 lb. of coal is 37⅓ ounces.

The heat that is given out during a chemical combination is capable, if applied either as heat, or mechanical force, or some other kind of energy, of again separating the constituent elements. The mechanical force which corresponds to the 8000 heat units above mentioned is 11,420,000 ft. lbs.; this quantity, therefore, represents the force with which the oxygen and carbon are bound together in 37⅓ ounces of carbonic acid. If, as is probable, all the carbon in existence has been derived from the decomposition of carbonic acid, the mind would fail to grasp the enormous expenditure of power necessary to the formation of coal only; the figures, however, may be arrived at by multiplying 11,420,000 ft. lbs. by the number of pounds of coal supposed to exist. The number obtained is so enormous that one is almost led to suspect that the agent which caused the separation must have been exceedingly energetic. It is difficult to believe that the combined action of sunshine and plants should be capable of effecting it, since the action proceeds so quietly and unobtrusively; and it is hard to believe that the effects produced during the calmest day by the sunshine and flowers can be greater than what could be done by all the noisy steam-engines in the world. Nevertheless, patient investigations have shown that it is so.

So far as we know there is no active power indigenous to the earth which is capable of separating carbonic acid into its elements at ordinary atmospheric temperatures; the only agent which effects it on a large scale is the light of the sun aided by plants, but at present we are unable to say how it is done. Our knowledge of the probable way in which the compounds of plants are built up indicates that some force is produced by the action of the light on the plant which entirely counteracts the attractive power of the oxygen for hydrogen and carbon, and at the same time enables the hydrogen and carbon to combine together. The articles GRAPHITE, E. C. S., and DIAMOND, E. C. S., may be consulted for additional details respecting carbon.

CARBONIC ACID. The properties of this gas have already been stated under CARBONIC ACID, E. C., A. & SCI. DIV.; but so important an agent is it in the general economy of life, and so abundant in the atmosphere, volcanoes, and springs, that an article respecting it seems to be requisite in this division.

Carbonic acid is the most highly oxidized form of carbon, and one of the most stable compounds known to the chemist. Together with water and ammonia it contributes to the maintenance and development of plants, and since plants are essential to the existence of animals, these three compounds may be regarded as the principal material mainstays of the whole organic world. They are the primary ingredients in the food of plants, from which are elaborated the extensive, varied, and complicated series of bodies which constitute the wood, sap, blood, fat, nerves, ligaments, &c., of all terrestrial life. So intimately are the functions of carbonic acid blended with those of water and ammonia that a full understanding of any one of these three compounds (so far at least as concerns their relations to living beings) can only be obtained by a consideration of all. This will be at once seen when it is remembered that carbonic acid, water, and ammonia are simple compounds; that by processes, of which we have only a dim conception at present, the carbon, oxygen, hydrogen, and nitrogen contained in them are built up into more complex molecules, such as cellulose, mannite, sugar, starch, albumen, &c.; that these complex molecules are assimilated by animals, broken up again by them into simpler molecules, and finally converted into carbonic acid, water, and ammonia. All the phenomena of animals and plants are consequences of the changes which occur between the two ends of this series. In the building up of the molecules by the plants there is a large expenditure of force derived directly from the sun, while the activity and power of animals is the utilization of this force as it is evolved during the conversion of the complex compounds into their simpler forms. This is not the place to dwell longer upon these general ideas. Our object in alluding to them is to impress upon the mind the fact that all the carbon which enters into the composition of plants and animals was originally derived from carbonic acid, and that the whole of it will sooner or later be again converted into it.

Although carbonic acid is perpetually entering into and streaming forth from the organic world, yet it takes very little part in any of the changes which occur between the absorption of carbonic acid by the plant, and the exhalation of carbonic acid from the animal. But there is another sphere in which this acid is an important mainspring of change, viz., the inorganic world; and in which it acts more directly.

The great bulk of the free carbonic acid on this globe is contained either in the atmosphere or in the water, so that this acid may be considered to be almost universal in its range. In both media the quantity present is constantly varying, although within very narrow limits. In the atmosphere the extremes are from 3 to 10 parts by volume in 10,000; and the average about 4 parts; in fresh water it may vary from almost nothing up to 1·5 per cent. by weight; and it constitutes about the 2000th part of the weight of sea-water at its surface, and about $\frac{1}{500}$th part of it at a depth of 350 fathoms; and probably a proportionately larger quantity at depths greater than this. In addition to this, we may here mention the exhalations of this gas, which are constantly issuing from volcanoes and fissures, and which, in the opinion of some authors, Bischof, for example, come from the interior of the earth. This last phrase is one repeatedly used in Bischof's 'Physical and Chemical Geology' (Cav. Soc. Transl.). In most passages it appears to mean the rocks situated beneath the surface; so that the source of the gas may in such case be only a few hundred or thousand feet down, but the general tenor of his remarks, more especially those on the atmosphere in Chap. X., seems to imply that the gas is evolved from much greater depths than this; and that it is an addition to the quantity already existing in the waters, animals, plants, and mineral substances.

Whether this acid be a fresh supply or derived from compounds contained in the strata, the enormous quantities of it which are discharged into the air over immense areas of ground are certainly remarkable. In Germany, for example, there are innumerable carbonated springs all along the mountainous country which forms the southern boundary of the states of Prussia and Saxony, that is from the Eifelgebirge and the district round Lake Laach, on the borders of France, to the Riesengebirge in Silesia, comprising an area of nearly 700 miles in length. There are also many districts farther north, both in the highlands and in the lowlands, which yield copious supplies of this gas. In some places, as, for instance, Burgbrohl, the soil is so permeated with carbonic acid that vegetation will scarcely grow upon it, that workmen have great difficulty in making excavations for buildings, that cellars cannot be entered, and that in certain depressions on the hill sides numbers of suffocated animals are always to be found. Near the village of Wehr are a number of springs which have formed a large marsh, through the water of which the gas bubbles up with a noise that may be heard from a considerable distance. Thousands of other instances could be cited; but we have said enough to show that the quantity of carbonic acid evolved from the ground every day is something almost incredible, even when our attention is confined to Germany. But this phenomenon is remarkable for its long continuance as well as for its universality; and doubtless it has lasted as long as the springs have flowed, which in many cases are known to be much the same now as 1800 years ago, and there is much reason to believe they may have flowed incessantly for several thousand years.

Where does all this gas come from? Some have suggested that it is simply the carbonic acid absorbed by meteoric water while sinking through the soil. As such water would absorb the gas under ordinary atmospheric pressure, and as the carbonated springs also flow out under a similar pressure, the maximum amount of gas in both cases should be nearly identical. But it is known that the volume of gas contained in the springs is three, four, or even seven times greater than that of the water when the gas is subjected to the ordinary atmospheric pressure. Since more gas comes up with the springs than is carried down by the meteoric waters, it is evident there must be some other source. There is, however, another point which seems to be an objection to this idea. The meteoric waters not only absorb carbonic acid, but also oxygen and nitrogen. It is very probable that all or nearly all the oxygen would be taken up in the work of oxidation, but no actions are known which would account for the absorption of even one-fiftieth of the nitrogen. And yet the gases evolved from many springs contain very small proportions only of nitrogen, whereas, if the carbonic acid had been derived from the atmosphere in the way supposed, at least 90 per cent. of nitrogen would be expected. It is principally for these reasons that Bischof, as we have stated, derives a large proportion of the supply from some unknown unfathomable depths.

CARBONIFEROUS LIMESTONE [CARBONIFEROUS SYSTEM, E. C. S.].

CARBONIFEROUS SYSTEM [E. C. vol. i. col. 776; COAL FORMATION, vol. ii. cols. 10—28; MOUNTAIN LIMESTONE, vol. iii. cols. 918—920]. The various members of this group of strata are treated under several heads in E. C. as indicated above. It seems preferable to place the supplementary remarks under the present heading mainly on the ground of propriety and convenience. The lower portion of the formation is usually termed the Carboniferous or Mountain Limestone, because it so happens that in England its most remarkable feature is the great development of calcareous beds, as, for instance, in Derbyshire and Yorkshire. When, however, the carboniferous limestone of any area is followed continuously over large horizontal spaces, it invariably becomes intermixed with impurities, interstratified with argillaceous and arenaceous beds, and dwindles away, until the strata representing this epoch consist of little else than clays, sandstones, and grits. This phenomenon is not special to the carboniferous limestone; for it is met with in the marine limestones of many other epochs, and a geologist should expect to meet with it in every age. The impropriety of calling the Lower Carboniferous formation by the term Carboniferous limestone is manifest when it is known that every limestone represents a special set of conditions during a particular period over a certain area, and that it is represented on other areas by sandstones, marls, clays, &c. Thus, as we shall have occasion to mention presently, the limestones which were formed in the central part of North America during the earlier half of the carboniferous period, are represented in the Appalachian mountains by detrital beds only. And further, the Upper Carboniferous formation consists of the coal measures in eastern portions of the United States, while in the far west, as in the Rocky Mountains, it probably consists chiefly of limestone, although several observers call this the carboniferous limestone. The carboniferous formation will be here considered as consisting of a lower and an upper half, each of which will be treated separately. The lower half comprises the Lower Limestone Shales, or Yoredale beds, and Carboniferous Limestone; and the upper half the Millstone Grit and Coal Measures of England.

LOWER CARBONIFEROUS FORMATION.

Limestones, doubtless, have various origins, and may indicate a fresh water area in one place and a marine one in another; but wherever formed they usually seem to imply that their particles have been aggregated by the agency of living beings in the midst of a quiet untroubled environment. It is probable, as has been urged by many authorities, that by far the greater proportion of limestones, more particularly such as have been formed beneath an ocean, have been deposited from solutions by means of plants and animals. Such a fact will appear amazing to any one who gazes upon the craggy precipices of Derbyshire, and recollects that in that county there is upwards of 5000 feet of limestone. The performance of such a work must have required the aid of myriads of creatures. Calcareous matter is being formed and deposited at all depths in the ocean; but it is only in places where there is little or no detrital matter in suspension that the sea floor consists of calcareous ooze. As it is now, so we may believe it has been from the period of the Laurentian limestones to those of the carboniferous and subsequent periods. Such localities as these are necessarily far from land; and in the present state of physical geography this is tantamount to being in deep water. But it would be hasty to infer that limestones are always the indications of a deep ocean at the spot where they were being formed: for it may well have happened that in some instances they were accumulated in shallow water in mid-ocean. The limestones, it will be seen, differ from ordinary sedimentary rocks in not being detrital and in being best developed in those localities to which no detritus is carried. Hence it happens that these two groups of rocks generally have an opposite relation to each other. Thus, if we start from a district in which the limestone was accumulated to a great thickness during a given epoch and follow it in the direction in which it diminishes, the strata will pass from thick beds to thin beds, from pure limestone to others which are more or less arenaceous or argillaceous; and advancing still farther the sands, clay, &c., gradually increase, and ultimately prevail to the exclusion of the calcareous matter. Illustrations abound in the lower carboniferous formation. In Derbyshire the limestone is estimated to be upwards of 5000 feet thick; in Lancashire and North Yorkshire it is 1500 feet; on the Scottish borders there are only 500 feet of limestone in the lower carboniferous series; in the Lothians 162 feet; and in Fifeshire we seem to have attained the calcareous limits. While, however, the limestones have been diminishing there has been no diminution in the thickness of the strata of the period; for it is more than compensated for by an increased development of sandstones and detrital strata. The materials composing them appear to have drifted from the north and west, and it is probable that their source was a large continent situated in the North Atlantic. If the limestones are followed in a southerly direction, they are found to diminish rapidly in thickness, and to rest on the older rocks of Charnwood Forest, or to disappear entirely before reaching Warwickshire and South Wales. The place of the limestone is not supplied by any other material, so that this, in conjunction with corroborative evidence of another character, indicates that portions of Leicestershire, Warwickshire, South Staffordshire, and South Wales, constituted a land surface at this period, probably as islands. Mr. Hull considers they formed a barrier separating the northern parts of England from the south. The calcareous limit in the south of England was on the areas of Pembrokeshire and Devonshire, and the limestone increased towards the east. The detrital rocks, on the other hand, increase from east to west, so that the source for their material lay in the west.

Crossing the channel into Belgium we find that the country round Namur is another region where the lower carboniferous series consists mainly of calcareous strata. Dupont has divided them into six *assises*, or zones, and has pointed out their lithological and palæontological peculiarities. Without admitting that his zones are necessarily of more than local value, we shall follow his description as it has a bearing upon the remarks already made. The *Assise d'Etroeungt* is the lowest and rests conformably upon Devonian strata. It consists of a dark compact limestone crowded with the fragments of crinoids, which is more or less interstratified with argillaceous schist. The schist is best developed near the base, where the limestone is fragmentary, spotted, and traversed by numerous veins of calcspar. Near the middle the limestone occurs in thicker beds, while the schists are few and far between. Near the top the limestone is interstratified with phthanite, and approaches a dolomite in character. The average thickness of the zone is about 500 feet, and the large proportion is calcareous. Next follows the *Assise d'Avesnelles*, which consists of a compact grey limestone, a dolomite, and a compact black limestone. The *Assise de Tournay* is principally limestone. It is generally siliceous, sometimes argillaceous. Its colour varies from pale grey to deep blue, and its thickness is about 300 feet. The lower part of the zone consists usually of a dark grey limestone, which is sometimes crystalline. The upper part is a bluish granular tough limestone. The *Assise de Waulsort* consists of a granular pale limestone. In its lower portion there are numerous geodes lined with crystals of calcspar; but there are none in the upper portion, which is more compact than the lower. The *Assise de Namur* is formed of dolomite alternating in places with bands of pure limestone. The *Assise de Visé* commences with a grey limestone passing into white. It possesses a subconchoidal fracture, and is much traversed by veins of transparent calcspar. It is surmounted by a dark grey limestone in which *Productus giganteus* attains its maximum. Towards the top there are some bands of dolomite; and the highest portion is a breccia, formed of limestone cemented by an argillo-calcareous and usually ferruginous matter. This brecciated structure is characteristic of this zone, being seldom met with in any other.

These zones are best developed in the south, and in passing north from Florennes the lower ones are overlapped by the higher, indicating that the calcareous matter spread farther towards the later portion of the period represented by these strata than at the beginning. The lowest beds, as we have noticed, are schists or shales; and if these are followed towards the north-east they thicken, while the overlying limestones diminish. When traced to Westphalia, on the opposite side of the Rhine valley, the coal measures there rest on shales and sandstones, which represent the lower carboniferous beds. These beds also die out towards the north-east, in which direction there was evidently land. This is confirmed by the mode of occurrence of the coal formation in Bohemia and Bavaria. It occurs in small isolated basins, some of which appear to have been the sites of ancient bogs. In the region round Prague and Pilsen the upper carboniferous rocks rest upon Silurian and older strata, to the entire exclusion of any beds representing the carboniferous limestone. It was either an island or an outlying portion of the land which existed at this time in the north, as is evidenced by the numerous stratigraphical breaks in Scandinavia and the high northern latitudes of Europe, where the carboniferous formation is unrepresented.

The State of Iowa represents in North America the set of conditions which prevailed in Derbyshire and Belgium; but the strata have most resemblance to those of Belgium already noticed. The Devonian sandstones and limestones are succeeded by the carboniferous limestones. These have been divided into groups, each group having a distinctive name. The Burlington limestone is the lowest. Its thickness diminishes towards the north, and increases towards the south. This feature is possessed by the other limestones. It has been further noticed that the northern limits of the younger beds lie south of those of the older and underlying strata; and that while the lower beds augment in thickness for a certain distance south, and then decline when traced further in the same direction, the higher beds possess their maximum of thickness further south than the localities where the lower limestones are thinning out. The *Burlington* limestone has a semi-crystalline structure; a grey, brown, and sometimes white colour; and is frequently friable in texture, from being composed almost entirely of crinoidal fragments with insufficient cementing material to cause them to cohere firmly. This feature is most conspicuous in the lower beds: higher up the crinoids are not so abundant, the beds become white, the shells of *Spirifer*, *Productus*, and other brachiopods are more profuse, and the stone itself far more compact. This is the Encrinital Limestone of Dr. Owen and Professor Swallow. Next follows the *Keokuk* or *Lower Archimedes* limestone. It is a grey or bluish-grey compact encrinital limestone, the beds of which are separated by shale partings. It thins out northward, and before its termination is quite subordinate to the argillaceous and arenaceous beds with which it is associated. At Keokuk this limestone is compact and heavy bedded; farther north it splits up readily into thin slabs, although no shaly matter is visible; but still farther north the shales set in. Above this follows (at Keokuk) calcareous shale or marl, which abounds with geodes of quartz and calcedony, and is hence termed the *Geode bed*. The *Warsaw* or *Second Archimedes* limestone succeeds. It is a dolomite below, a shaly arenaceous limestone in the centre, and a yellow coarse calcareous sandstone above. South of Keokuk the arenaceous beds above, and the dolomitic layers below, gradually disappear; while the central members alone spread over a large area in Iowa and the states bounding it towards the south. The *St. Louis* limestone follows next. At Keokuk it has a brecciated concretionary structure, which is a frequent feature in limestones where they thin out. In some places in Iowa it is a compact grey limestone, alternating with bands of a compact ash-coloured limestone; while south of this state it rarely presents the brecciated structure. This is the highest portion of the lower carboniferous series in Iowa. Farther south, as at Kaskaskia, in Illinois, the St. Louis limestone is covered by a ferruginous sandstone; and this is succeeded by the *Kaskaskia* limestone, which in its lower portions is much intermixed with sandstones and shale. On comparing the strata of Belgium and Iowa there is a remarkable resemblance in their lithological nature and sequence. If they had occurred in contiguous countries, most geologists would have concluded that they were contemporaneous deposits, and some would draw the same conclusion as regards the strata we have compared, although they are thousands of miles apart. It seems to us that there is no proof here of contemporaneity, but rather of similarity of conditions. The same coincidence of agreement frequently occurs with strata of two different geological epochs, as for instance between the carboniferous rocks of California and the lower Silurian beds near Lake Superior. There is one important point of difference between them; the limestones of Belgium overlap, which indicates an extension of the limestone area towards the north and probably a depression of the Belgian area. In Iowa, on the other hand, the younger limestones did not reach so far north as the older ones, which indicates a contraction of the limestone area and probably the elevation of the land towards the north. Deferring for a while the consideration of the question of the contemporaneity of these beds, we will quote some remarks by Professor Hall, from Hall and Whitney's 'Geological Survey of Iowa,' vol. i., part i., in connection with the carboniferous limestones of that state:—

"The difficulties which have occurred in the way of reconciliation of the views of western geologists, as expressed in their several reports, have arisen in part from the fact that these different limestones have not an equal geographical distribution; there being no point on the Mississippi within our knowledge where a transverse section of this valley will embrace, within a moderate distance, all the beds here enumerated. The limestones likewise change their characters when examined in a north and south direction, owing to causes which will be explained. The fossil forms which have mainly been relied upon for establishing divisions have been mostly of general value only, and specific differences have not always been fully appreciated. The lowest of the series, the Burlington limestone, has, as already shown, a greater extension northward than either of the succeeding groups; and its gradually thinning edges stretch far towards the northern limits of Iowa. Near this latitude was the northern boundary of the ancient ocean, or, at least, the limit of its fauna. Considerably to the southward of this we first find the attenuated northern edges of the Keokuk limestone, mingled with much earthy sediment, and often consisting of a few thin beds of encrinital limestone intercalated among other beds of shale and clay. It is only further south, in the neighbourhood of Nauvoo and Keokuk, that this limestone first exhibits decidedly its characteristic features. The limits of the ocean which admitted of rock deposition and the support of animal life at this period, apparently never extended so far north by many miles as in the period of the Burlington limestone. The Warsaw limestone and its associated beds of magnesian limestone and calcareous sandstone appear to have been nearly co-extensive in a northerly and easterly direction with the limestone below so far as at present known. The northern extensions of this group, however, are shaly and arenaceous, and apparently destitute of organic remains. The St. Louis limestone extends nearly or quite as far north as the groups below, but only as a thin, brecciated, conglomerated mass; and it is only in the neighbourhood of Alton, Illinois, that we find this rock in any considerable force. In the Missouri section this limestone is given as 250 feet thick, while in southern Iowa it is less than 50 feet. The Archimedes limestone of the same section, corresponding with and including the Keokuk and Warsaw groups, has a thickness of 200 feet; while in its more northerly outcrop its entire thickness does not exceed 50 feet, and is less than this in many places. The Burlington limestone, which does not exceed 100 feet at Burlington, Iowa, is given in the Missouri section as 500 feet thick. Nor is the augmenting thickness the only evidence of deeper seas and more quiet waters; for as we go southwards the coarser sediments and mixtures of shale and sandstone, prevailing on the northern outcrop, disappear in great part or entirely, and the whole series has a calcareous character. In the geographical distribution and the changes of lithological characters at different points we have yet much to learn from local investigation and comparison. . . . . These facts warrant the conclusion that the entire series of the carboniferous limestones were successively deposited in an ocean, the limits of which were gradually contracting upon the north, while at the south the conditions were becoming more and more favourable to the development of this kind of deposition, and to the support of the fauna which abounded throughout this period, until both culminated in the great limestone formation of Kaskaskia. This rock is known for its abundance of fossils throughout Kentucky, Tennessee, and Alabama; while it has not been found to extend so far north as the Burlington limestone by four or five degrees of latitude. The centres of greatest development, both of deposition and of animal life, were constantly being transferred farther to the south at each successive epoch here indicated; and while the greatest development of the Burlington limestone is to the north of, or about the latitude of St. Louis, that of the Kaskaskia limestone is on the south of the Ohio in Tennessee and Alabama" (p. 111). In those states it forms the greatest part of what is there called carboniferous limestone, and in Tennessee it is estimated by Professor Safford to be 1200 feet thick. After some remarks on the strata of Alabama and Tennessee, the same author further observes (p. 116) that "it is well known that no limestones of the age of these here described occur upon the west side of the Appalachian coal-field on the north of the Ohio river, nor upon the eastern side of the same field to the north of the central portion of Virginia. The same is true of the coal-fields of Nova Scotia and New Brunswick, according to Professor Dawson, the northern sides exhibiting no underlying limestones; while such rocks do appear coming out from beneath the coal measures on the south-easterly side. The same phenomena occur also with regard to the coal-fields of Iowa and Illinois. The northern and north-western margins of these coal measures extend beyond the limits of the carboniferous limestones. At the same time I have ascertained, in the most satisfactory manner, that the coal-fields of Iowa, Missouri, and Illinois, rest uncomformably upon the strata beneath, whether these strata be carboniferous limestones, Devonian, Upper Silurian, or Lower Silurian rocks. It would appear that at a period long preceding the commencement of the carboniferous limestone deposits, the ancient ocean began to contract its area; that this contraction was consequent upon the uplifting of the older rocks upon the north, and that this state of things continued throughout all the period of the limestone deposits. Furthermore, we have evidence that during this period, or at its close, and previous to the deposition of the coal measures, the older strata, which had long previously been raised into numerous anticlinal axes with corresponding depressions, and along some lines broken by faults, and dipping at various angles, had to some extent been worn down by denudation, which also produced other inequalities of the surface; and that afterwards the coal measures were spread out over the thinning and slightly inclined edges of the carboniferous limestone beds, and the edges of the more highly inclined rocks of the preceding periods. Facts indicate very clearly, as we conceive, that the area of the ancient ocean, which had been contracting up to the coal period, was thus extended in this part of the country by the sinking of the land on the north, allowing the deposits of the coal measures to be spread over much wider areas, particularly in that direction, than the preceding formations of the carboniferous limestones. This will explain, in a very satisfactory manner, the cause of the absence of the carboniferous limestones on the northern margins of all the coal fields of the west, and at the same time suggests an explanation of the greater accumulation of conglomerates and coarser materials in the same relative position. Should the carboniferous limestones of Nova Scotia prove to be of the same age as the carboniferous limestones of the west and south-west, their occurrence so far to the northward of the northern limits of the Appalachian coal-fields may still be explained by supposing the line of ancient coast, or the line of coral reefs, to have had an irregular direction from the south-west to the north-east, following the undulations caused by unequal depression and elevation; and it may have been interrupted by the elevation of the Green Mountain and Appalachian chain, which, if not entirely cutting off the continuity of the carboniferous sea, must have been deflected by the course of the limestones very far to the southward. The supposition of this former continuity will furnish, at the same time, an explanation of those limestone areas in Rhode Island and Massachusetts, which have been, with hesitation, referred to the carboniferous period. It is not improbable that this may have been the direction of the coast line at that period, since we know that in the west its course was irregular, extending farther to the north in some points than in others. Thus we have in Iowa the carboniferous limestone reaching to the north of latitude 42° 30′, while from this point it trends to the south-east, as is seen by following its out-crop through Iowa, Illinois, and Indiana. Beneath the Appalachian coal-field I am not aware that the carboniferous limestone has been traced far to the north of latitude 38°, though its existence has been indicated somewhat farther in the same direction. It is quite evident, therefore, that a broad deep river has existed in the outlines of the carboniferous limestone, or, in other words, that a broad extension of land (or of sea too shallow for coral reefs) stretched from the north into the ocean of the carboniferous limestone, in the position and in the direction, very nearly, of the present Cincinnati axis; while on the west of that line, the lower carboniferous limestone made a northerly bend, as if at that period the area of the present valley of the Mississippi admitted of a more northerly extension of the coral reefs. About 10° farther east, or in Pennsylvania, the lower carboniferous series is composed of about 6000 feet of shales, sandstones, and conglomerates. This points to the existence of a continental area on the north and west of the present site of the United States, that is, in the North Atlantic." The main purpose we have had in view in penning the above paragraphs has been to show that the sea bottom of the lower carboniferous period was not a universal calcareous ooze, but that it had as varied a character as the present. In pursuing this object we have indicated a method by which it would be possible to ascertain roughly the approximate positions and, in part, the outlines, of the principal masses of land which then existed. Our material and space will not permit of our following up this inquiry, but enough has been said to show that the land was more abundant in the polar than in the equatorial half of the northern hemisphere.

Passing over many interesting points connected with what may be termed the physical geography of the period, such as comparative stratigraphy, the occurrence of gold in a drift of this age, the presence of carboniferous limestone in the Caucasus, and many others, we will rapidly glance at a few facts connected with the fauna. Of the flora there is little to be said, for but little is known. The Protozoa are very scantily represented, a feature which is very remarkable as regards the hard-shelled forms, such as the foraminifera. The principal genus is *Fusulina*, which is, with the exception, perhaps of *Eozoon*, the earliest representative of the nummuline family; a family which possesses a more complicated shell structure than any other in the foraminiferal group. The genus is said by Lyell ('Elements of Geology,' p. 518) to be peculiar to and characteristic of the mountain limestone in England, United States, Arctic America, Russia and Asia Minor. The same species, at least nominally, is supposed to range over all this area. In Missouri, Kansas, Illinois, and probably one or two other neighbouring states, this genus is present in the coal measures only, the species being the same, or very similar. In Missouri, for instance, *Fusulina cylindrica* ranges from the top to the bottom of the coal measures, or upper carboniferous series, occurring in nearly every limestone band; whereas it is unknown in the well-developed limestones which underlie them, and represent, as is believed, the lower carboniferous series. The other species living at the time belonged to the genera *Nodosaria*, *Endothyra*, and *Textularia*. From these facts it would seem that whereas each of the three families into which Dr. Carpenter has arranged the members of the sub-order *Perforata* [FORAMINIFERA, E. C. S.] is represented, there is nothing to show that any form belonging to the other and simpler group, or that with the imperforate test, had any existence. This result is, however, probably due to the insufficiency of evidence, but, if correct, it is noticeable. Sponges are represented by numerous spiculæ found in the masses of hornstone so frequently met with in the carboniferous limestone.

The Cœlenterate sub-kingdom has afforded numerous species, but all, or at any rate the great majority, belong to the Actinozoon class. Adopting Bronn's modification of Milne-Edwards and Haime's classification as the most convenient, although it may not be quite correct, we will arrange our remarks in accordance therewith. The first feature that strikes us is the great predominance of the order *Rugosa*, a feature that was recognized by Professor Forbes when he distinguished the fossil corals into the Palæozoic and Neozoic types. The difference between these types is usually stated to consist in the older forms having their parts, such as the septa, built up in multiples of four, and those of more modern date in having an hexapartite arrangement. Such a difference would probably warrant the separation of the *Rugosæ* as a distinct order, and even their removal from the Zoantharian to the Alcyonarian sub-class. According to Ludwig's investigations the difference is not so great. Both types are hexapartite in structure; but in the older forms the septa were so asymmetrically developed that those belonging to four of the primary chambers grew more rapidly than those of the other two. The result was that only four of the principal septa were conspicuous. If this view be correct, then the *Rugosæ* are not entitled to ordinal rank, but most of the genera composing it would find their natural places in the families of the order *Aporosa*. In either case, however, it still remains true that the Palæozoic corals are remarkably different in appearance from those of Neozoic times; and that most of the carboniferous species belong to the Palæozoic type. In the one case the word type would imply a difference in the plan of structure of the corallum, but in the other only a modification of the same plan.

The *Rugosæ* consist of four families. The *Cystiphyllidæ* flourished in pre-carboniferous times, and as yet are not known either in or above the carboniferous formation. The *Cyathophyllidæ* contain about 40 genera, of which about 18, or nearly half, are represented in the lower carboniferous. They are *Axophyllum, Lonsdaleia, Phillipsastræa, Lithostrotion, Lithodendron, Stylaxis, Chonaxis, Cyathophyllum, Aulophyllum, Cyclophyllum, Clisiophyllum, Campophyllum, Amplexus, Lophophyllum, Menophyllum, Zaphrentis, Aulacophyllum,* and *Trochophyllum;* of these *Lonsdaleia, Cyathophyllum, Clisiophyllum, Zaphrentis,* and *Aulacophyllum,* occur in the underlying Silurian and Devonian strata; *Lithostrotion, Amplexus,* and *Lophophyllum* commence in —that is, have not yet been found lower than—the Devonian, and the remainder are restricted to the carboniferous formation. *Lonsdaleia floriformis* appears to have an extensive horizontal range, and yet in each country its vertical range is by no means great. Thus Ludwig reports it from the Spirifer limestone of Ursia Prisk near Lithwinsk, and Nischni Parogi on the Uswa in Perm; Huxley and Etheridge record it from Somersetshire on the south to Shropshire and Denbighshire on the north, while the neighbouring county of Flint yields *L. rugosa,* and *L. duplicata.* In Murchison's 'Siluria,' p. 299, a figure is given of a specimen of *L. floriformis* found at Lilleshall, Shropshire, the lower parts of which are rooted in shale, while the mass of it is in limestone; a fact which indicates that the specimen retained the position it had during its lifetime. A species is mentioned in Hall and Whitney's 'Geol. Survey of Iowa,' which appears to be this or an allied species; but, although frequently referred to it is scarcely called twice alike. Assuming then that *Lithostrotion floriforme, L. canadense, L. basaltiforme, L. basaltica,* and *L. mamillare* refer to one species, as the context seems to imply, and that *Lithostrotion floriforme* is a synonym for *Lonsdaleia floriformis,* we may say that this species is characteristic of the St. Louis limestone, or the higher portion of the lower carboniferous series in the Mississippi valley. In some counties of Southern Iowa it is the only fossil in this part of the series. It is most abundant in the lower part of this bed, but in Illinois it predominates in the upper portion. It appears to have the same stratigraphical position in Alabama and Tennessee. This is one of the very few genera of this class mentioned in the lower carboniferous strata of North America. In the highest part of the lower carboniferous series of Namur, or the 'Assise de Visé' of Dupont, occur the nearly allied forms *Lithostrotion junceum* and *Lithodendron fasciculatum.* The former species also occurs in England, Wales, and Ireland. *Lithostrotion basaltiforme,* of Conybeare and Phillips, occurs in Derbyshire, and Koninck reports it from the Punjaub; in both which far separated localities it is associated with *Lithodendron irregulare. Cyathophyllum* ranges through all the beds, and some species extend from Great Britain to Russia. Thus in Perm we find *C. Stutchburyi, C. regium, C. arietinum, C. multiplex, C. calamiforme,* and *C. boloniense. C. Stutchburyi* occurs in Somersetshire and Gloucestershire; *C. regium* extends from Gloucestershire to Lanarkshire; *C. Murchisoni* and *C. Wrightii,* are also English species, while *C. ceratites,* occurs in Tyrone, and *C. plicatum* in Lanarkshire. It remains for future inquirers to ascertain if we have any indication here of what was the geographical distribution of the genus. We imagine not, although we have chosen to place the facts in the above form. *Cyclophyllum fungites, C. Bowerbanki,* and *Aulophyllum Edwardsi* occur low down in the formation in Scotland; *Clisiophyllum* is represented by the species *turbinatum* and *coniseptum* in England; *Keyserlingii* in the 'Assise de Visé' in Belgium; and *indicum* in the Punjaub. *Amplexus* affords one of the most characteristic species in the carboniferous limestone. The distribution of *A. coralloides* in the strata of Belgium has been well indicated by Dupont. It is rare or absent in the lowest part of the series, where indeed there appears to be a dearth of corals. It is first observable as a rare fossil in the lower portion of the third stage, or 'Assise de Tournay,' but is more common in the upper half. It increases in frequency in the lower half of the next stage, or 'Assise de Waulsort,' and towards the top it becomes so abundant that the zone or horizon is distinguished as that of *A. coralloides* and *Rhynchonella pleurodon.* In the fifth and sixth stages, or those of Namur and Visé, it presents a marked decline, but may be expected to ascend one or two stages higher wherever rocks of that age are found. The other species are rare, and have a limited range. Thus, *A. serpuloides,* Koninck, occurs in the 4th stage, or 'Assise de Waulsort'; *A. cornubovis,* in the 5th, or 'Assise de Namur,' and *A. nodulosus* and *A. Henslowi* in the 6th, or 'Assise de Visé.' In England *A. coralloides* ranges from the south to the central counties, and is also found in the south of Ireland. *A. Henslowi* and *A. Sowerbyi* also occur in Ireland, and the last mentioned species has been reported from Derbyshire. *Zaphrentis* has species in various localities between Russia on the east to Illinois on the west.

The family *Cyathaxoniadæ* comprises but one genus, *Cyathaxonia,* which is a carboniferous form. The family *Stauriidæ* contains but few genera, but none are, so far as we know, of carboniferous age.

The order *Tabulata* consists of between 30 and 40 genera, and many of them belong to the period under consideration. They are *Rhabdopora, Harmodites, Syringopora, Chætetes, Beaumontia, Favosites, Emmonsia, Michelinia, Alveolites, Fistulipora,* and *Propora.* The family *Theciidæ* has no representatives. The *Seriatoporidæ* is represented by *Rhabdopora,* a genus restricted to the carboniferous formation. All the other genera named belong to the *Favositidæ. Harmodites,* which embraces several forms usually assigned to *Syringopora,* extended from Russia to Western Europe. One of the commonest species is *H. ramulosus,* which occurs in the carboniferous limestone of Perm; in the Assise de Visé, in Belgium; at Matlock, in Derbyshire; and in Ireland. *Chætetes tumidus* occurs on the same horizon in Belgium, and is found in Fifeshire and Tyrone. *Michelinia favosa* is another of the species found in the highest part of the carboniferous limestone at Visé; it has been found in England, Wales, and Ireland; and Koninck has seen a single specimen brought from what are probably lower carboniferous strata in the Salt Range of the Punjaub.

The order *Tubulosa* comprises but one family, and probably but one genus; for *Aulopora* appears to be simply a young stage of *Syringopora.* That genus is *Pyrgia,* which is restricted to the carboniferous formation.

The next order is that named *Aporosa.* Nearly 200 genera belong to it, but only two extend into the carboniferous epoch. A species of *Stylastræa* is said to occur in the carboniferous limestone of Kendal, Westmoreland; and *Isastræa arachnoidea* in that of India; but in both cases further evidence seems to be required.

The order *Perforata* is represented only by the genus *Astræopora.* Thus in the 'Catalogue of Fossils in the Museum of Practical Geology,' by Messrs. Huxley and Etheridge, mention is made of *A. cyclostoma* and *A. antiqua.*

The *Echinodermata* appear to have swarmed in the older carboniferous seas, but the various orders were very unequally represented. Thus, of the seven orders into which this class may be subdivided, viz., *Blastoidea, Cystidea, Crinoidea, Ophiuridea, Asteridea, Echinidea, Holothuridea,* the brittle stars (*Ophiuridea*), and the sea cucumbers (*Holothuridea*), have no representatives; while very few species belong to the starfishes (*Asteridea*) and sea urchins (*Echinidea*).

The *Blastoids* comprise very few species. The order attained its maximum development in the carboniferous period, and then rapidly declined, since it is almost unknown in later strata. The principal genus is *Pentremites,* which is abundant in the rocks of this age, both in Europe and America. It is by a careful comparison of the distribution of the species of genera of this kind that a clue can be best obtained of the relations between the strata of widely separated areas. Without pretending to give a complete account, we may nevertheless summarise such notes as we have been able to collect, bearing upon the distribution of this genus. The species occurring in the lower carboniferous rocks of Yorkshire are *P. inflatus, P. acutus, P. ellipticus, P. angulatus, P. oblongus, P. orbicularis, P. pentangularis, P. Dutertrii, P. astræformis.* In Hainault, Belgium, the genus is represented by *P. Puzos, P. inflatus, P. crenulatus, P. Orbignyanus, P. caryophyllatus,* and *P. Waterhousianus.* In Illinois there occur *P. Godonii, P. pyriformis, P. sulcatus, P. Norwoodi, P. lineatus, P. elongatus, P. Koninckana, P. melo, P. stelliformis.* In Iowa there occur all the species found in Illinois, with the exception of *P. lineatus;* and, in addition *P. conoideus, P. laterniformis, P. curtus,* and *P. planus.* Most of the neighbouring states possess one or more of the Iowan species. The North American species appear to have had a greater horizontal range than those of Europe; so that we do not find the same degree of difference between the species of two distant areas in North America as is perceptible in Western Europe. The vertical range of the American species is not great, so that generally each division of the lower carboniferous series has its own distinctive form. Thus in Iowa the Burlington limestone yields *P. Norwoodi*, *P. melo*, *P. stelliformis*, *P. elongatus*, *P. Sayi*, and *P. planus*. In Illinois the Encrinital limestone, which rests upon Devonian strata, contains *P. lineatus*, *P. elongatus*, *P. melo*, *P. stelliformis*. The Encrinital limestone of Missouri contains *P. Sayi*, *P. Norwoodi*, *P. melo*, and *P. stelliformis*. The Warsaw limestone of Iowa contains *P. Konincki* and *P. conoideus*; which two species are also found in the Archimedes limestone of Illinois, and in that of Indiana, in conjunction with *P. pyriformis*, *P. laterniformis*, and *P. Grosvenori*. The Archimedes limestone of Missouri has yielded *P. Godonii*, *P. sulcatus*, *P. pyriformis*, *P. conoideus*, and *P. curtus*. The Kaskaskia limestone of Iowa contains *P. Godonii*, *P. pyriformis*, *P. sulcatus*, *P. laterniformis*, and *P. curtus*. From these facts we should infer the equivalency of the Burlington limestone with the Encrinital limestone, and of the Archimedes limestone with both the Warsaw and Kaskaskia limestones—an inference which is abundantly supported by other evidence. There is nothing whatever, so far as this genus is concerned, which indicates any specific relation between the European and American strata. In Iowa and in the neighbouring states the species of *Pentremites* occur throughout the whole series of limestones; but in Belgium they are only known in the uppermost beds, and are by no means common even in them.

The Cystids have few representatives in this group of rocks, and these are amongst the latest relics of the order, which reached its maximum development in pre-carboniferous times.

The Crinoids swarmed in the old carboniferous seas, and were far more abundant, both in species and individuals, than any other order of Echinoderms. Their principal development, at least individually, appears to have been at the beginning of this period, for the lowest beds of the carboniferous limestone, both of North America and Western Europe, comprise beds which are little more than thick masses of crinoidal fragments rendered coherent by a greater or less proportion of cementing material. Thus the lowest limestones of this age in Belgium are designated by Dupont and others the 'calcaire à crinoïdes'; and the Burlington limestone of Iowa equally deserves this appellation. The lowest limestones of the carboniferous series of Great Britain are also remarkable for the abundance of crinoidal remains.

Rhodocrinus is represented in North America and Western Europe. In Iowa, *R. Wortheni* occurs in the Burlington limestone; in Belgium, *R. uniarticulatus*, and *R. stellaris* occur in the highest portion of the carboniferous limestone; and in the British Isles *R. stellaris* and *R. abnormis* have only been found high up in the series. The American species most resembles *R. stellaris*, like which it has the outer surfaces of the plates granulated, while in *R. uniarticulatus* they are smooth. *Woodocrinus* is represented by the species *macrodactylus*, which has been obtained from the highest part of the series in Yorkshire. *Poteriocrinus* is one of the most abundant genera in the European beds; but it is by no means rare in those of North America. In Europe the species are most numerous in the upper portion, and in America in the lower portion of that series; but in both areas the genus is generally distributed both vertically and horizontally. So far as we know, only one species is common to the two continents, but this may be simply an identity of name, not of species. Thus Hall and Whitney mention *P. gracilis* from the Kaskaskia limestone of Illinois; and Morris and Roberts record it from the limestone at the very base of the series in Shropshire. If the same species be alluded to in each case, it flourished in the lowest part of the carboniferous limestone in one area, and the highest in the other. *Cyathocrinus* is not abundant in Europe, but in America some 15 or 20 species have been described, most of which were found in the lower beds. *Zeacrinus* is more abundant in North America than in Europe; and in the former country it is better represented in the higher than in the lower beds. *Agassizocrinus* is restricted to the higher strata in North America. *Scaphiocrinus* has also only been recorded from North America; but as it has a considerable range there, it may probably have existed in Europe. *Actinocrinus* is the commonest genus, and is represented by numerous species, both in Europe and North America. These are distributed through all parts of the lower carboniferous areas; but they are most abundant and best developed in size and beauty of ornamentation in the lower beds in North America, and the higher in Europe. The groups of species from the two areas present a generally different appearance, although in both we meet with the same kind of variation. Very few of the species of one area have a close resemblance to those of the other. Amongst the few instances that occur to us are *A. costus* and in a less degree *A. tenuis* of Europe, and *A. sculptus* of North America; as also *A. triacontadactylus* of Europe and *A. pentagonus*. In both areas there are species with smooth, or nodular, or ridged, or spiniform plates; with shallow, depressed, or deep urn-shaped cups; with small and low, or large and high cup-covers; but amongst the American species there seems to be a greater prevalence of nodular plates, of cups with truncated bases, and of basal plates which overhang the stem or pedicle. *Megistocrinus* and *Agaricocrinus* are sub-genera of *Actinocrinus*, which chiefly prevail in the lower beds. *Platycrinus* is another numerously represented genus which ranged from Europe to America, and which, like most of those already mentioned, predominated in the upper beds in Europe, and in the lower in North America. There is a greater general resemblance between the two groups of species than is perceptible in *Actinocrinus*. Thus the *P. planus* of Europe is very much like the *P. planus* of Iowa, the few differences which exist being slight. In the European form the places for the insertion of the arms are wider and deeper than in those of the American individuals; while the edge is raised and crenulated in the former, but not in the latter. The *P. pileatus* of Belgium and England closely resembles *P. pileiformis* of Iowa; *P. granulatus* of Ireland, England, and Belgium, reminds us of *P. pocilliformis*, and in a less degree of *P. cavus*, both which latter are found in North America, and a few other instances might be cited. Even in the case of these nearly allied species it is noticeable that those of America occur near the base of, while those of Europe occur high up in, the carboniferous limestone. *Dichocrinus* is common to both continents, and in both has a nearly similar range. Thus it is rare in the lower beds, but more abundant in the middle and upper part of the carboniferous limestone.

The Asteroids, which are not plentiful in precarboniferous strata, are very rare in those under consideration. A minute species, *Cribellites carbonarius*, has been discovered in the upper portion of the carboniferous limestone of Northumberland. It had a disc of about one-third of an inch across, and the expanse of its rays was one inch and a half. It is similar to the recent *Cribella rosea*.

The Echinids comprise seven or eight families, of which one is exclusively Palæozoic, viz., the *Palæchinidæ*, or *Tessellati*. It contains six genera, of which *Archæocidaris* and *Palæchinus* have representatives in the carboniferous limestone. The former occur both in Europe and North America, and is generally distributed in the vertical direction. In Iowa each division of the series has its peculiar species. Thus *A. Agassizi* belongs to the Burlington limestone; *A. Keokuk* to the Keokuk limestone; *A. Shumardiana* to the Warsaw limestone; *A. Wortheni* to the St. Louis limestone; and *A. Norwoodi* to the Kaskaskia limestone, which occurs in Illinois, a little south of Iowa. *Palæchinus* also occurs in both continents; several species have been recorded from Ireland, and a few from North America, but none appear to be common to the two areas. *Cidaris*, which belongs to an allied family, is found in the carboniferous limestone of Belgium and of India.

From this general and imperfect summary of the distribution of the Echinoderms, it appears that very few species are common to Europe and America; and that the closest connection, palæontologically, is between the inferior half of the lower carboniferous series of North America, and the superior half of the same series of Western Europe.

The *Annelida* are feebly represented in the fossil state in these strata; most of the species have been assigned to *Serpula* and *Spirorbis*, but as the determination is necessarily based upon characters afforded by the shell, and as the shell does not afford the means of making reliable diagnoses in the living species, it is doubtful if the carboniferous forms are or are not correctly collocated in the same genera with the living representatives of the above-mentioned genera. The curious track marks of this age, frequently attributed to annelids, were probably made by crustaceans. The want of definite and sufficiently numerous facts prevents any general statements being made respecting this class.

The Crustaceans have afforded a very small proportion of the known fauna of this period, and consist, for the most part, of *Entomostraca*, and the majority of these were apparently denizens of brackish or estuarine waters. They abound most in those strata which contain terrestrial plant remains, or which possess other indications of the proximity of fluviatile currents. Some of the genera, such as *Cythere* and *Bairdia*, are represented by living species; while others, such as *Cytherella*, *Cypridella*, &c., do not differ much from recent genera. The principal generic forms were *Estheria*, *Leperditia*, and *Phillipsia*, all of which had a wide geographical range, species having been recorded from North America and Western Europe. The *Estheria striata* occurs at Hof in Bavaria, and Visé in Belgium; a variety, *Tateana*, is met with in the highest part of the series at Lammerton in Berwickshire, and allied species are found in the lowest beds in Nova Scotia. *Leaia Leidyi* occurs low down in the series in Nova Scotia and Pennsylvania, and the same species, or rather a variety of it, *Salteriana*, is reported from Fifeshire. *Leperditia subrecta* is common to Nova Scotia and Scotland; and in the latter country there also occur *L. Scotoburdigallensis*, *L. inflata*, *L. inornata*, and other species. *Phillipsia* is also common to the old and new worlds, but it appears to have been more numerous in the former than the latter. One species, *P. gemmulifera*, ranges from the bottom to the top of the carboniferous limestone of Western Europe, but is abundant only in the middle portion of it. *P. Jonesii*, *P. seminifera*, and *P. globiceps* are also common in the middle beds.

Several Polyzoan genera flourished during this period, and a few, *Fenestella*, for example, were so abundant, that whole beds were formed almost exclusively of the remains left by them. *Fenestella* appears to have had a world wide range, for it is represented in India, Europe, and North America. In the Vihi valley, West Himalayas, some of the lowest beds of the lower carboniferous series are little more than layers of *Fenestella* fragments. In North America the individuals are so abundant that one stratum is called the 1st Archimedes limestone, another the 2nd Archimedes limestone, while a third, which occurs near the summit of the series, and is usually called the Kaskaskia limestone, contains them more abundantly than any other, and would be more appropriately named Archimedes limestone, than those which have been so called. *Archimedes*, we should mention, is a synonym for *Fenestella*. In Iowa the Keokuk limestone is characterised by *F. Owenana*, and the Warsaw limestone by *F. Wortheni*. The St. Louis limestone of Missouri, which is somewhat like the two last-mentioned, contains *F. hemitrypa* and *F. banjana*, and the carboniferous limestone of the Organ Mountains, Texas, which appears to be on a similar horizon, has afforded several allied species, such as *F. trituberculata*, *F. Popeana*, *F. corticata*, *F. intermedia*, *F. variabilis*, *F. Shumardii*, *F. Norwoodiana*, *F. subretiformis*. The species which occur in Western Europe are different from these: and they appear to be most concentrated towards the middle of the series. Thus Dupont makes no mention of the genus in the lowest beds in Belgium; and the first record of it in the upward direction is in the 'Assise de Tournay,' in the lower half of which *F. plebeia* and *F. membranacea*, are abundant, while *F. ejuncida* and *F. fastuosa* are rare. In the 'Assise de Waulsort' *F. plebeia* and *F. multiporata* are common, while *F. osculata*, *F. ejuncida*, *F. membranacea*, *F. fastuosa*, and *F. ripisteria* are rare. Most of the Belgian species extend into the British Isles. The most important genera next to *Fenestella* are *Polypora* and *Coscinium*, both of which occur in America and Europe, but in very few instances are the species common to both. One of these, *Coscinium cyclops*, is remarkable since it is said to be in Devonian strata at the fall of the Ohio in North America, whereas it has only been found in carboniferous rocks in Europe. *Berenicea*, *Ceriopora*, *Discopora*, *Glauconome*, *Hemitrypa*, *Phyllopora*, *Ptylopora*, *Retepora*, and *Vincularia*, also had representatives in the older carboniferous series.

The Brachiopoda forms one of the most important portions of the older carboniferous fauna. From no other group of strata have so many species been recorded as from the carboniferous; and no other class of mollusca is so abundant individually, although specifically the brachiopoda are outnumbered by most. Thus in Great Britain the brachiopoda predominated over every other molluscan class in the pre-carboniferous eras; but although they increased greatly in numbers, so far as genera and species are concerned, during the carboniferous period, they were outstripped by the other classes. Thus the *Lamellibranchiata* were more than twice as numerous in species; the *Gasteropoda* much more numerous, and the *Cephalopoda* about as numerous. According to Etheridge the number of British species of mollusca of the whole of the carboniferous period was in 1867 as follows:—

Lamellibranchiata	334
Gasteropoda	174
Brachiopoda	157
Cephalopoda	145
Nucleobranchiata	29
Pteropoda	1

Another fact indicative of the declining importance of the group, even during this period of its maximum specific development, is that while twelve genera appeared for the first time in the Devonian strata, every one of the sixteen carboniferous genera are represented in pre-carboniferous formations, and four of them, namely, *Orthis*, *Strophomena*, *Cyrtia*, and *Retzia*, are not known to ascend higher. The most numerously represented genera are *Productus* and *Spirifer*, and these, as also *Chonetes*, *Athyris*, *Retzia*, *Spiriferina*, and *Camarophoria* here attain their maximum specific development.

The family *Terebratulidæ*, with its numerous genera, is represented only by species of the genus *Terebratula*, which, however, are sporadically distributed over a great area. If we are to trust the determinations of palæontologists it would seem that most of the species on each area are distinct, while one or two occur almost everywhere. Four or five species are recorded as British, namely, *T. hastata*, *T. elongata*, *T. sacculus*, *T. vesicularis*, and *T. gillingensis*. The first mentioned is the most remarkable for its abundance, wide distribution, and retention of traces of its original coloured pattern. It is found in Ireland, in the lowest part of the series in Scotland, in England, in all parts of the carboniferous limestone of Belgium (being most abundant in the upper half), in Russia, and in other localities. *T. sacculus* has a yet wider range, occurring in several places between Kashmere on the east and Nova Scotia on the west. The most abundant species in the Himalayas are *T. himalayensis*, and *T. subvesicularis*.

The *Spiriferidæ* are exceedingly well represented in rocks of this age, and, next to the *Productidæ*, afford more species than any other family. Most of the sub-genera belonging to it were living. As in the case of the preceding family, most of the species appear to be local forms, while a few are found almost everywhere. Of the genus *Spirifer* twenty-seven species have been found in Great Britain; while Dupont mentions thirty-three species as occurring in Belgium. As the latter author has recently published an elaborate memoir showing the ranges of the fossils in the carboniferous limestone of Belgium, we will indicate what the succession was in that country, in order that it may be compared with the distribution of the species in Iowa. Dupont recognises six stages in the carboniferous limestone as already indicated. In the lowest or 'Assise d'Etrœungt,' *S. Verneuili* and *S. mosquensis* occur in the basement beds, which contain a large number of Devonian species. In the higher beds the species met with are *S. mosquensis*, *S. pinguis*, *S. laminosus*, *S. octoplicatus*, the last mentioned being rather common. In the 'Assise d'Avesnelles' *S. mosquensis* is the only recorded species. This form ascends into the 'Assise de Tournay.' In the lower half of this stage it is very abundant, while all the other species hereafter enumerated are rare: *S. glaber*, *S. lineatus*, *S. octoplicatus*, *S. bisulcatus*, *S. ovalis*, *S. pinguis*, *S. distans*, *S. Rœmerianus*, *S. striatus*. In the upper portion *S. convolutus* is the commonest species; *S. lineatus*, *S. planatus*, and *S. pinguis* are less abundant; and the following are rare, namely, *S. glaber*, *S. insculptus*, *S. triradialis*, *S. octoplicatus*, *S. bisulcatus*, *S. rhomboidalis*, *S. duplicicosta*, *S. laminosus*, *S. cuspidatus*, *S. striatus*, and *S. mosquensis*. In the 'Assise de Waulsort,' *S. striatus* is very abundant; *S. lineatus*, *S. bisulcatus*, *S. pinguis*, and *S. cuspidatus*, are common; while the rare species include *S. urii*, *S. glaber*, *S. insculptus*, *S. octoplicatus*, *S. ornatus*, *S. ovalis*, *S. planatus*, *S. distans*, *S. fusiformis*, *S. Rœmerianus*, *S. laminosus*, and *S. mosquensis*. In the 'Assise de Namur' there occur *S. pinguis* and *S. bisulcatus*, both of which are rare. In the 'Assise de Visé' *S. lineatus* and *S. glaber* are abundant; *S. pinguis*, *S. bisulcatus*, and *S. octoplicatus* are common; and *S. triradialis*, *S. Buchianus*, *S. acuticostatus*, *S. crassus*, *S. recurvatus*, *S. pectinoides*, *S. duplicicosta*, *S. sublamellosus*, *S. striatus*, *S. subconicus*, *S. trigonalis*, *S. convolutus*, *S. Fischerianus*, *S. cheiropteryx*, *S. bronnianus*, *S. ornatus*, *S. ovalis*, *S. Schnurianus*, *S. insculptus*, and *S. triangularis* are rare.

In the Iowa district the Burlington limestone contains *S. Forbesi*, *S. imbrex*, *S. incertus*, *S. plenus*, *S. Grimesi*, *S. Sowerbyi*, *S. ventricosus*. The Keokuk limestone contains *S. tenuimarginata*, *S. rostellatus*, *S. Keokuk*, *S. suborbicularis*, *S. pseudolineatus*, *S. subcuspidatus*, *S. propinquus*, *S. striatus*, var.? *S. Logani*, *S. imbricatus*, *S. ovalis*. In the Kaskaskia limestone there are *S. setigerus*, *S. spinosus*, *S. increbescens*, and *S. incrassatus?* Of these it will be noticed that a few are common to Iowa and Belgium. They are *S. striatus* and *S. ovalis*. In Belgium both species range from the 'Assise de Tournay' to the 'Assise de Visé,' the former being abundant in the 'Assise de Waulsort,' and rare at all other levels, while the latter is rare at all horizons. In Iowa they are apparently restricted to the

Keokuk limestone. *S. striatus* is represented by a variety, which Hall believes will prove to be a distinct species. Supposing it to be a variety, this species has a very extended range, for it is one of the species from the lower portion of the carboniferous limestone of the Punjaub. *S. glaber* is another wide-ranging species, which occurs in all parts of Great Britain, and also in Nova Scotia. *Spiriferina* is represented by four British species. One of them is mentioned by Dupont as *Spirifer insculptus.* Another is *S. cristata,* which occurs in the lower carboniferous limestone of Nova Scotia, and is represented in the rocks assigned to the same formation at Moosakhail, in the Punjaub. *Cyrtia* has two or more British species, and one of these, *C. carbonaria,* is rare in the upper part of the carboniferous limestone of Belgium. *Athyris* has eight or nine British species, viz. *A. ambigua, A. expansa, A. microgemma, A. lamellosa, A. planosulcata, A. subtilita, A. globularis, A. Roysii,* and *A. oblonga.* Only three species are mentioned by Dupont from the corresponding strata of Belgium. *A. Roysii* is rare in the lowest beds, attains its maximum of abundance in the middle, or in the upper part of the 'Assise de Tournay,' and then declines. Where most abundant it is associated with *A. planosulcata,* which is rare at this level, but becomes more abundant towards the highest part of the series, where it is joined by *A. lamellosa* in very small numbers. No mention is made of such species as *A. subtilita,* which would be expected to occur here. The species just named is another cosmopolitan form. It occurs by millions in the lower carboniferous limestone of Shubenacadie, and other localities in Nova Scotia; and a variety of it is exceedingly abundant in the lowest beds of Kashmere, in Iowa and in New Mexico. *A. lamellosa* is abundant in the Keokuk limestone of Iowa, where it is associated with *A. squamifera.* There are three British species of *Retzia,* viz., *R. radialis, R. ulotrix,* and *R. carbonaria.* The former two also occur in the higher part of the series in Belgium, but are nowhere abundant; and a variety of the first mentioned is rather abundant in the Punjaub. The Iowa and Illinois species are also reported from the higher beds only; but neither are identical with those of Europe. *R. Verneuilana* occurs in the Warsaw limestone, and *R. vera* in the Kaskaskia limestone.

The *Rhynchonellidæ* are represented by the genera *Rhynchonella* and *Camarophoria;* 14 species of the former and 5 of the latter are British. Of the *Rhynchonellæ* the most abundant are *R. pleurodon* and *R. pugnus.* Both occur in India, and *R. pleurodon* is possibly found in Nova Scotia. The last-mentioned species is said to be abundant in the lowest carboniferous limestones at Farlow, Shropshire, but in Belgium it is rare in the lowest half of the series, but abundant in the upper half.

The *Orthidæ* contribute some British species belonging to *Orthis, Strophomena,* and *Streptorhynchus. O. interlineata, O. Michelini, O. filiaria, O. Keyserlingiana, O. resupinata,* are the names of the species of *Orthis.* The principal Belgian species are *O. arachnoidea, O. resupinata,* and *O. Michelini,* there being seven or eight others. *O. arachnoidea* is rare in the lower beds, becomes abundant in the 'Assise de Tournay,' and is rare in the 'Assise de Waulsort,' and is not known above this horizon. *O. resupinata* is rare in the lowest beds, rapidly increases, is abundant in the lower half of the 'Assise de Tournay,' attains its maximum in the upper half of the same, and remains abundant to the summit of the series. *O. Michelini* is not recorded from the lower beds; but it is very abundant in the lower part of the 'Assise de Tournay,' rare in the upper part, and very rare at all higher horizons. It is probable that *O. Michelini* does occur in the lowest beds, since it is met with in the lowest carboniferous strata of Devonshire and Ireland. A shell which is scarcely distinguishable from this species occurs in the Burlington limestone of Iowa, Illinois, and Missouri. The same limestone also contains *O. Swallovi,* which closely resembles *O. resupinata.* The principal species of *Streptorhynchus* is *S. crenistria,* which occurs throughout the whole Devonian series, is present in the lower carboniferous strata of all parts of Britain, and is recorded by Davidson from various localities in India as well as from the lower carboniferous shales of Nova Scotia. In Belgium it is common in the lower beds of the carboniferous limestone, and rare in the higher. A variety, *robustus,* is said to occur in the carboniferous limestone at Vurcha, Punjaub, and in the lower coal measures of Illinois. The British species of *Strophomena* are *S. analoga,* which also occurs in Nova Scotia, and *S. rhomboidalis.* The former is, however, frequently considered to be a variety of the latter; it is rare at the base of the lower carboniferous series in Belgium, becomes more abundant in the middle, and declines again towards the top.

The *Productidæ* are represented in the British Isles by 41 species of *Productus,* and 7 of *Chonetes.* The ranges of the *Producti* in Belgium are thus indicated by Dupont. In the 'Assise d'Etrœungt' there are—*P. scabriculus,* var., *P. semireticulatus, P. cora, P. Flemingii, P. pustulosus.* In the 'Assise d'Avesnelles' there occur—*P. cora, P. semireticulatus,* and *P. Heberti.* In the lower portion of the 'Assise de Tournay,' *P. Flemingii* is the predominant species; *P. semireticulatus* and *P. aculeatus* are common; and *P. elegans, P. mesolobus, P. fimbriatus, P. pustulosus, P. scabriculus, P. plicatilis,* and *P. margaritaceus,* are rare. In the upper half of the same horizon *P. mesolobus* is the most abundant species of this genus; *P. plicatilis, P. semireticulatus, P. Flemingii, P. pustulosus, P. fimbriatus,* and *P. aculeatus,* are common: while *P. margaritaceus, P. sublævis, P. scabriculus,* and *P. punctatus,* are rare. In the 'Assise de Waulsort'—*P. semireticulatus, P. fimbriatus,* and *P. aculeatus,* are the prevailing species; *P. mesolobus, P. pustulosus, P. Flemingii, P. plicatilis, P. cora,* and *P. margaritaceus,* are common; and *P. Nystianus, P. Humboldtii, P. costatus, P. elegans, P. punctatus, P. scabriculus,* and *P. sublævis,* are rare. In the 'Assise de Namur'—*P. semireticulatus, P. giganteus,* and *P. cora,* are common. In the 'Assise de Visé'—*P. punctatus* is most abundant; *P. striatus, P. giganteus, P. margaritaceus, P. Buchianus, P. undatus, P. plicatilis, P. semireticulatus, P. costatus, P. Flemingii, P. pustulosus, P. marginalis, P. Keyserlingianus,* and *P. aculeatus* are common; and *P. latissimus, P. flexistria, P. arenarius, P. undiferus, P. ermineus, P. Griffithianus, P. proboscideus, P. Nystianus, P. medusa, P. sublævis, P. expansus, P. spinulosus, P. tessellatus, P. scabriculus,* and *P. mesolobus,* are rare.

In Iowa the Burlington limestone has yielded *P. Flemingii, P. semireticulatus,* and *P. punctatus,* all of which are abundant, more especially the first mentioned. The Keokuk limestone has yielded *P. semireticulatus, P. alternatus, P. cora, P. punctatus, P. Wortheni, P. mesialis, P. setigerus,* and *P. vittatus.* The St. Louis limestone contains *P. altonensis.* It will be noticed that there are several species common to the two countries; but the facts seem hardly sufficient to enable us to test the contemporaneity of the beds. *P. semireticulatus* and *P. Flemingii,* are found in the lowest beds of both; but *P. Flemingii* only is common at this horizon in Belgium. These two species occur in the lower part of the 'Assise de Tournay,' where both of them are common; they are both common in the upper half of the same stage, but *P. punctatus* is rare; and it is only in the highest stage, that of Visé, that the three species are common. The nearest resemblance, then, is between the lowest or Burlington limestone of Iowa, and the highest or Visé limestone of Belgium. This also harmonises with the fact that in Iowa the genus is best represented in the lower half of the lower carboniferous series, but in the upper half of the same in Belgium. Moreover, we have already noticed the same correlation in the case of other families. Some of the species also range into Nova Scotia and India; *P. cora, P. semireticulatus,* occur in Nova Scotia; and these species, as also *P. scabriculus, P. Humboldtii, P. longispinus, P. striatus,* and *P. Purdoni,* are found in the carboniferous limestone of North India. *Aulosteges* and *Strophalosia* are represented by a few species in Russia and India. The British species of *Chonetes* are *C. comoides, C. convoluta, C. tuberculata, C. Hardrensis, C. sulcata, C. papilionacea, C. concentrica.* In Belgium—*C. variolata, C. elegans,* and *C. sulcata,* occur in the 'Assise d'Etrœungt,' the first-mentioned being common. In the lower portion of the 'Assise de Tournay,' *C. variolata* is rare; and *C. comoides* and *C. papilionacea* occur in the upper half, both being rare. In the 'Assise de Waulsort,' *C. papilionacea* is common; and *C. elegans, C. variolata, C. concentrica,* and *C. perlata,* are rare. In the 'Assise de Visé,' *C. papilionacea, C. tuberculata,* and *C. Buchiana,* are common; and *C. sulcata, C. Dalmaniana, C. comoides,* and *C. concentrica,* are rare. *C. Hardrensis* is not mentioned among the Belgian species; but a variety, *Thibetensis,* is exceedingly abundant in Kashmere. *C. lævis* and *C. Austeniana* are also Kashmere species. *C. Logani* is an Iowa and Illinois species, which resembles *C. variolata;* it occurs in the Burlington limestone. *C. Illinoiensis* is a species from the carboniferous limestone of Illinois.

The family *Craniadæ,* with its single genus *Crania,* is represented by three British species. The *Discinidæ* are represented by two British species, viz., *Discina cincta* and *D. nitida.* The *Lingulidæ* are represented by six British species, all belonging to the genus *Lingula.*

The other classes, viz., the *Lamellibranchiata*, *Gasteropoda*, *Pteropoda*, and *Cephalopoda*, each had their representatives; and the details afforded by these show, what has been repeatedly pointed out already, that while each country has its own forms, a few species have extensive latitudinal ranges; and that few, if any of them, can be relied on as indicative of the contemporaneity of the strata in Europe and America. The evidence, so far as it goes, seems to point to the conclusion, that the upper portion of the lower carboniferous series in Europe is the palæontological representative of the lower portion of the same series in America; but it will require much further investigation before that conclusion can be accepted.

Upper Carboniferous Formation.

In the general division of the carboniferous system into the carboniferous limestone group below and the coal measure group above, we recognise the prevalence of marine conditions in the one case, and of more or less terrestrial conditions in the other. Such an arrangement is represented in its typical form in many parts of England, but if it was strictly applicable to all the world, it would follow that the sea prevailed everywhere during the earlier half of the carboniferous period, while the land made its appearance above the water during the later half. This, however, is known not to be true, for in the British Islands, not to speak of many other countries, the carboniferous system when traced northward comprises a gradually increasing proportion of shallow sea-shore and terrestrial strata, so that the system becomes more and more a system of coal measures, while the marine limestones diminish and disappear. Could we map the world during the successive phases of this period, it would, we confidently believe, be found that the carboniferous limestone, the millstone grit, and the coal measures were being developed in their typical form during every part of this period. These terms must then be regarded as temporary, to be retained until the confusion is sufficiently great, or rather sufficiently felt, to compel the adoption of better ones. Illustrations of their inconvenience are already cropping up. Thus we have the upper and lower coal measures of England, both of which belong to the upper carboniferous formation; the lower coal group of Scotland, which belongs to the upper portion of the lower carboniferous formation; and in Nova Scotia we find an upper coal formation, a middle coal formation, and the lower coal measures. The former two belong to the highest part of the upper carboniferous formation; while the third constitutes the base of the lower carboniferous formation. Unless, then, a person be acquainted with the geology of England and Nova Scotia, he might be misled into supposing that the lower coal measures of these two countries were in the opinion of geologists the chronological representatives one of the other. In most of the areas, however, which have been explored the coal measures generally prevail towards the summit of the system, and it is in this part of the series that we have the most abundant evidence of the existence of land. As none of the strata before or after, prior to the tertiary era, have afforded so much information as to the terrestrial inhabitants of former epochs, we take this opportunity of making a few general remarks respecting these old worlds and the beings which they supported. The remarks will mostly refer to the upper carboniferous formation, but we shall have occasion now and then to compare them with what existed in the lower carboniferous formation.

During this period, and in many of those which preceded it, the principal land surfaces on the present British area appear to have been central England and the northern portion of Scotland. The English surfaces were probably islands lying off a large continent situated towards the north-west. The evidence on this point is of various kinds—such as stratigraphical breaks, the distribution of coal resting on underclays, the gradual increase or decrease of the strata in certain directions, the denudation of beds after the deposition of the carboniferous limestone and before that of the Permian series, &c. A few illustrations of each kind will serve to show that a systematic study of the facts would develope many interesting features in the geography of the carboniferous world. In the Shrewsbury coal-field the coal strata rest on pre-carboniferous rocks, and in a narrow valley about 18 miles long and one mile wide. The strata belong to the uppermost portion of the coal measures, and are remarkable for a thin band of limestone which abounds in estuarine and marine organisms. This band has been traced into Lancashire and Warwickshire, or over an area of about 10,000 square miles. The lower portion of the coal measures is not developed. The coal-fields of the Titterstone and Brown Clee Hills in Shropshire also belong to the higher coal measures, and rest on Devonian or old red sandstone rocks, and, like most of the beds of this period which are supported by pre-carboniferous strata, are situated upon elevated ground. There is, we believe, such a relation between the degrees of development of the carboniferous series and the vertical contour of the ground, that a map which indicated the respective areas where the carboniferous limestone is overlaid by the coal measures, where earlier rocks support these measures, and where carboniferous rocks appear not to have been deposited, would indicate the low level, middle level, and high level grounds of this period. The low level district would be that which was most persistently submarine, the middle level that which was less persistently submarine, and the high level that which remained permanently above the waters. Such a map would, moreover, give a generalised outline of the extent to which the land oscillated above and below the sea level of the carboniferous period. The break in Shropshire is traceable for many miles to the east; thus in South Staffordshire the middle coal measures rest directly upon upper Silurian rocks; in Warwickshire the lowest strata found belong to the millstone grit, so that whether the carboniferous limestone is or is not developed is uncertain; in Leicestershire the carboniferous limestone is very feebly developed and rests on Cambrian rocks, while the upper coal measures are absent between the middle coal measures and the Permian breccia. The only probable relics of them are some patches of grit, which seem to bear witness to an extensive denudation of this area at the close of the carboniferous epoch. This band of country from Shropshire to Leicestershire, and perhaps farther east, was highland during a greater or less portion of this period; and along it the sea, or rather marine deposits, appear to have encroached inland from the east towards the west. Similar phenomena are apparent in proceeding southwardly or northwardly from Shropshire and Central Wales. How far this land may have extended towards the south and east is not known. The few facts bearing upon the subject rather countenance the view that the whole of the south of England was then land. Thus the lowest beds of the Bristol coal-field die out towards the east, a phenomenon which in itself proves little, but suggests that the higher beds also may disappear in their easterly extension beneath the secondary strata. The pebbles of the post-carboniferous deposits south and east of the Staffordshire and Gloucestershire coal-fields are formed of pre-carboniferous rocks; and the deep well borings at Harwich and Kentish Town have revealed a great gap in the succession of strata, which gap may, or may not, represent the carboniferous series.

Every coal-seam is a proof of the existence of land during the period of its formation; and in the majority of cases it occupies a portion of its surface. That coal has generally been formed from vegetable matter which grew in situ, and not from such as may have been drifted, is now generally admitted by most authorities; but there are some, as, for instance, Professor Jukes, who maintain that most coal-fields are accumulations of transported matter, whether that matter be carbonaceous or detrital. The objections to the 'growth in situ' theory are detailed by Professor Jukes in his memoir on the South Staffordshire Coal Field, to which we would refer the reader, while the arguments in support of the same theory are concisely stated by Principal Dawson in his 'Acadian Geology' and other publications, which we quote, premising, however, that they are mainly founded upon the phenomena presented by the Nova-Scotian coal-fields. "The occurrence of *Stigmaria* under nearly every bed of coal proves beyond question that the material was accumulated by growth in situ; while the character of the sediments intervening between the beds of coal proves with equal certainty the abundant transport of mud and sand by water. In other words, conditions similar to those of the swampy deltas of great rivers are implied. The true coal consists principally of the flattened bark of the Sigillarian and other trees, intermixed with leaves of ferns and *Cordaites*, and other herbaceous débris, and with fragments of decayed wood constituting 'mineral charcoal,' all these materials having manifestly alike grown and accumulated where we find them. The microscopical structure and chemical composition of the beds of cannel coal and earthy bitumens, and of the more highly bituminous and carbonaceous shales, show them to have been of the nature of the fine vegetable mud which accumulates in the ponds and shallow lakes of modern swamps. When such fine vegetable sediment is mixed, as is often the case, with clay, it becomes similar to the bituminous limestone and calcareo-bituminous shales of the coal measures. A few of the underclays which support beds of coal are of the nature of the vegetable mud above referred to; but the greater part are argillo-arenaceous in composition, with little vegetable matter, and bleached by the drainage from them of water containing the products of vegetable decay. They are in short loamy and clay soils, and must have been sufficiently above water to admit of drainage. The absence of sulphurets and the occurrence of carbonate of iron in connection with them, prove that when they existed as soils, rain water, and not sea water, percolated them. The coal and the fossil forests present many evidences of sub-aërial conditions. Most of the erect and prostrate trees had become hollow shells of bark before they were finally imbedded, and their wood had broken into cubical pieces of mineral charcoal. Land-snails and galley-worms (*Xylobius*) crept into them, and they became dens or traps for reptiles. Large quantities of mineral charcoal occur on the surfaces of all the large beds of coal. None of these appearances could have been formed by subaqueous action. Though the roots of *Sigillaria* bear some resemblance to the rhizomes of certain aquatic plants, yet structurally they are absolutely identical with the roots of Cycads, which the stems also resemble. Further, the *Sigillariæ* grew on the same soils which supported Conifers, *Lepidodendra*, *Cordaites*, and ferns—plants which could not have grown in water. Again, with the exception, perhaps, of some *Pinnulariæ* and *Asterophyllites*, there is a remarkable absence from the coal measures of any form of properly aquatic vegetation. The occurrence of marine or brackish water animals in the roofs of coal beds, or even in the coal itself, affords no evidence of subaqueous accumulation, since the same thing occurs in the case of modern submarine forests. For these and other reasons, some of which are more fully stated in the papers already referred to, while I admit that the areas of coal accumulation were frequently submerged, I must maintain that the true coal is a subaërial accumulation by vegetable growth on soils wet and swampy, it is true, but not submerged. I would add the further consideration, already urged elsewhere, that, in the case of fossil forests associated with the coal, the conditions of submergence and silting up which have preserved the trees as fossils, must have been precisely those which were fatal to their existence as living plants—a fact sufficiently evident to us in the case of modern submarine forests, but often overlooked by the framers of theories of the accumulation of coal. It seems strange that the occasional inequalities of the floors of the coal beds, the sand or gravel ridges which traverse them, the channels cut through the coal, the occurrence of patches of sand, and the insertion of wedges of such material splitting the beds, have been regarded by some able geologists as evidences of the aquatic origin of coal. In truth, these appearances are of constant occurrence in modern swamps and marshes, more especially near their margins, or where they are exposed to the effects of ocean storms or river inundations. The lamination of the coal has also been adduced as a proof of aqueous deposition; but the microscope shows, as I have elsewhere pointed out, that this is entirely different from ordinary aqueous lamination, and depends on the superposition of successive generations of more or less decayed trunks of trees and beds of leaves. The lamination in the truly aqueous cannels and carbonaceous shales is of a very different character." If then coal seams generally mark the site of former soils, it is manifest that a large portion of Great Britain, Europe, Northern Asia, North America, and probably other districts, coincides with the carboniferous land.

The argument in favour of a carboniferous 'Atlantis,' based upon the attenuation of strata, has been referred to in the case of the carboniferous limestone; and Mr. Hull has worked out the same argument with reference to the later carboniferous rocks. For instance the coal measures are 1810 feet thick in South Staffordshire; 2500 feet in Leicestershire; 3500 feet in South Derbyshire; 5000 feet in North Staffordshire; and 6800 feet in Lancashire. This shows a general increase in the thickness towards the north-west; and in Scotland the coal measures increase in their north-westerly extension. The coal-fields on the southern side of the supposed Central England barrier of land show a rapid increase in thickness towards the west; thus the coal measures of the Bristol coal-fields are 5125 feet thick; while those of Glamorganshire are upwards of 11,500 feet thick. In both fields the strata are almost exclusively detrital, limestone being absent or rare.

In the North American coal-bearing or upper carboniferous strata, the rocks become coarser in texture, and more massive, towards the east and south-east; and in support of this statement we append the observations of Professor H. D. Rogers:—"Comparing in the first place the rocks of mechanical origin as they occur in different districts, we almost invariably find them coarsest and most massive towards the south-east, and more and more fine grained and less arenaceous as we pursue them across the successive parallel basins north-west. Thus in the anthracite coal-fields, which are the most south-eastern of all, the coal is interstratified with a vast thickness of rough and ponderous grits, and coarse siliceous conglomerates, but is associated with very little soft clay-slate or shale. In this region the coal slates themselves are more than ordinarily arenaceous, and bear a smaller proportion to the sandstones than in the basins more to the west. At the same time, the coal rocks, viewed in the aggregate, acquire a finer texture in going west, the individual strata undergo a corresponding reduction in thickness, while many of them entirely thin away. I may cite, as a striking instance of these changes, the great coal-conglomerate itself, which forms the general base of the main or upper coal-measures. This massive rock is chiefly composed of large quartzose pebbles imbedded in coarse sand. Adjacent to its most south-eastern outcrop in Pennsylvania—that is to say, in Sharp Mountain, where it constitutes the boundary of the first or Pottsville basin—it has a thickness of nearly 1500 feet; but in the mountains which embrace the Wyoming coal-field, about 30 miles to the north-west, the thickness of the formation is only 500 feet; while still farther across the chain, where it becomes the general floor of the coal-measures under the bituminous form, in the basins north-west of the Alleghany Mountains, its entire thickness seldom exceeds 80 or 100 feet. Tracing it across the great western coal-field, until we encounter its last outcrop in Western Pennsylvania, Ohio, and Kentucky, this wonderfully expanded rock dwindles to a thin bed of sandstone, sprinkled with a few pebbles, its whole thickness amounting generally to only 20 or 30 feet. There is a corresponding and quite as striking a diminution in its constituent fragments, the pebbles in the most south-east belts of the formation being often as large as a hen's egg, while in the north-west their diameter is reduced to that of a pea. A similar gradation obtains in the thickness and coarseness of nearly all the interstratified sandstones and other mechanical members of the formation. I conceive that this interesting fact, fully established by the surveys of Pennsylvania and Virginia, shows beyond all question, that the south-east was the quarter whence the coarse materials of the coal rocks were derived. But there are not wanting other proofs that the ancient land lay in that direction; these will be presently detailed in describing the gradations witnessed in the limestones and beds of coal. The above general law of distribution relates, it should be observed, only to the coarser mechanical aggregates, since there are some apparent exceptions to its generality among the finer grained slates and shales. Though the texture of these continues to grow finer as we advance west, some of the strata, when individually traced, seem to increase for a certain distance in thickness. This curious circumstance, which belongs, indeed, to many of the more argillaceous members of our Appalachian formations, so far from invalidating the above inferences respecting the west transportation of the sediments, comes beautifully to confirm them, since it is evident that until a current, holding in suspension a quantity of sedimentary matter, declines in velocity to a certain point, it cannot let fall any considerable amount of the smaller particles. After it has reached a given degree of retardation, the finer materials will subside, and in an increasing quantity, up to a certain point, at which the loss of velocity in the current is compensated by the exhaustion of material, whence gradual and final thinning of the deposit will take place. If we examine in the next place the gradations of thickness visible in the limestones and other marine deposits, they will be found to lead to precisely similar inferences respecting the position of the ancient land. Viewed either together or individually, the limestones of the coal measures of Pennsylvania, Virginia, and Ohio, display a remarkably uniform augmentation as we trace them westward. Thus, throughout all the south-east basins, comprising the whole of the anthracite coal-fields of Pennsylvania and the Broad Top Mountain in the same state, the formation exhibits a total absence of limestone, and a corresponding deficiency of calcareous matter in the shale and iron ores. Advancing, however, a distance of 25 or 50 miles north-west to the general south-east margin of the great bituminous region, where we enter on the first of the chain of partially insulated troughs, adjacent to the escarpment of the Alleghany Mountains, we no longer encounter a total poverty of limestone, though we still meet with a striking deficiency. As an evidence of this, let us take one of the basins of the Alleghany Mountains—that, for example, which lies near the head of the Potomac river. The minute researches there made, in connection with the geological surveys of Virginia and Pennsylvania, have shown that the total thickness in the limestones, counting all the thin bands and layers of nodules, does not probably exceed 10 feet. This statement is confirmed by a pamphlet on the same coal-field, describing the land of the George's Creek Company, by Messrs. Alexander and Tyson. In their very full section of the strata we do not see a single band of limestone introduced. Turning to the Moshanon basin, in Centre County, which is also a marginal trough of the great west coal-field, the entire quantity of limestone appears to be about 7 or 8 feet. If, however, we pass west from this south-east line and cross the great coal-field by any section between the Susquehanna in Pennsylvania and the Little Kenawha in Virginia, we witness a regularly progressive expansion of the calcareous rocks." After some details, showing that the limestones increase from zero in the Broad Top basin to 200 feet at Wheeling, beyond the Monongahela river, the Professor goes on to notice that the conclusions drawn from the limestones and detrital rocks mutually support each other. He next deals with the phenomena presented by the coal seams. Many of them are of a very slight extent; but there are not a few, more especially the thicker seams, which have an extraordinarily wide outspread.

One seam, for example, known as the Pittsburg coal, has been traced over an elliptical area 225 miles across in one direction, and about 100 miles in another; so that its superficial continuous extent would be about 14,000 square miles. The same seam is, however, present in several outlying portions of the coal measures, so situated as to imply a former area of at least 30,000 square miles. How much larger it may have been cannot be estimated owing to the extensive denudation of the margins of the coal area. This seam is remarkably uniform in its thickness over considerable spaces, but taken as a whole it thins out gradually from 2 feet in the west to 12 or 14 feet in the east; the increase is less towards the south-east than towards the north-east, indicating that it was in the latter direction that the uplands were situated. Considering then how vast is the bulk of the material which has been transported to form the upper carboniferous formations of Great Britain and North America, and knowing that many of the later and earlier British strata were derived from a western source, land must have formerly been far more abundant in the North Atlantic than it is now.

Not only must the land have been extensive that supplied our coal measures, for a series of islands would not have been sufficient, but denudation must also have been very great. Denudation, or rather the effect of denudation, is, in our opinion, as important a clue to the physical geography of this period, and indeed of all periods, as stratigraphy. Stratigraphy is the study of the distribution and succession of strata, and has been deservedly much cultivated by geologists; the study of denudation indicates the amount of material which has been removed, and the periods during which such removal took place, and should be, but is not, the constant handmaid of stratigraphy. To dwell upon the stratigraphy is to tell half the story only; for to complete the cycle we ought to follow the material in its journeyings from resting-place to resting-place. The defect is apparent and easily pointed out, but it is a far more difficult matter to remedy it. The pre-carboniferous and carboniferous rocks are much denuded, but how much of that denudation took place in carboniferous times? We can, however, mention one or two minor cases of denudation as they support to a certain extent the terrestrial origin of coal. In many coal-fields the seam of coal is suddenly interrupted by a patch of sandstone or clay, which phenomenon is variously called "horse," "horse back," and "rock fault." Many cases of this kind are the filled up channels of a river or stream which flowed across the coal seam. De la Beche has described one in Gloucestershire as consisting of a channel from 130 to 340 yards in breadth, which has been traced for two miles in a south-easterly direction. Connected with and debouching upon it are a series of smaller and shallower channels. The whole arrangement is remarkably like a river system, the sandstone being cast in the valleys of excavation. Similar, but smaller, rock faults occur in the Leicestershire coal-field. Jukes mentions one in the coal-field of South Staffordshire, in which the slope of the sides was about 7°, and the depth in the centre at least 60 feet. He distinguishes a second kind of rock fault, which was formed by local hillocks around which the coal was formed. One or two other cases of carboniferous river valleys are mentioned in a subsequent part of this article.

In connection with denudation as evidence of land surfaces, we would mention the "boulder" bed at the base of the Talcheer group in the Cuttack district of India, although its precise age is uncertain. At present it appears to belong to the later part of the palæozoic epoch, and may be carboniferous, permian, or pre-mesozoic. It rests upon gneiss, and is apparently distributed in patches. It consists of large blocks of granite and gneiss, some of which are five feet in diameter, imbedded in a matrix of variable fineness of grain. Sometimes it is a coarse sandstone, and at others it is an exceedingly fine shale. The blocks are for the most part rounded and without any apparent traces of striæ. In the sandstones associated with them there are a great many small irregular and angular lumps of shale, of a kind similar to the shales imbedded with the sandstones. As no older sedimentary strata have been found in the immediate district it is difficult to account for the origin of this shale. But there is a phenomenon, of common occurrence in some of the large rivers of India of the present period, which throws some light upon it. During the dry season they diminish so much as to become converted into a series of large shallow pools. The fine sediment collects in these, and a portion of the mud round the edges becomes hardened by the sun. When the river is in flood, large fragments of the mud are carried down the river and deposited in places where sand usually collects. If these conditions coincided with a cold winter temperature the action of shore ice would effect the same result.

So far as these few facts admit of an opinion being formed, we should conjecture that the boulders, previously rounded by attrition, had been transferred to the "boulder bed" by the action of shore or ground ice in a river, or in a lake near a river; and that they belong to what we have termed the fifth mode of occurrence of boulders, under Boulders, E. C. S. cols. 163, 164. This, together with the suggested explanation of the angular fragments of shale, would imply a climate liable to mild frosts in winter, and to considerable heats in summer; a climate somewhat like that now existing in Thibet, that is, in a country a few degrees to the north of Cuttack.

Such are a few details bearing upon the existence and location of the land of this period; but before we enter upon a consideration of its inhabitants, we will add a few supplementary remarks to the accounts already given [Coal Formation, E. C.] of the stratigraphy of the coal-fields of North America. In so doing we propose to take up each district in North America, beginning with those on the east and ending with those on the west, and following them up generally from the north towards the south.

The first district, then, that calls our attention is Nova Scotia, where the upper carboniferous series is arranged in three divisions by Dr. Dawson. (1.) The lowest is the 'Millstone grit formation,' which consists of sandstones, shales, and conglomerates, with little or no coal, and but few plants. Red and soft beds prevail in the lower part, and beds of coarse grey sandstone in the higher part, which sandstone frequently contains trunks of the conifer, *Dadoxylon Acadianum.* Its thickness is between 5000 and 6000 feet. (2.) The 'Middle Coal Formation,' or coal measures proper, overlies the first division, and contrasts with it and the highest division, in that the beds are of a more neutral tint, and not ruddy. The strata chiefly consist of dark shales and grey sandstones, while conglomerates are absent. The principal beds of coal are in this division, but, as is implied in the name, there are coals above it and below it. The lower series forms the lowest portion of the lower carboniferous series, occurring indeed below what is considered to represent the carboniferous limestone. The most prevalent fossils are *Sigillariæ*, *Stigmariæ*, *Filices*, *Cordaites*, *Calamites*, *Entomostraca*, *Anthracomya*, and *Spirorbis*. The total thickness is about 4000 feet. (3.) The 'Upper Coal Formation' consists of sandstones, shales, and conglomerates, associated with a few bands of limestone and coal. The larger number of the beds are stained red, and alternate with others of a grey tinge. The principal plants are *Calamites Suckovii*, *Annularia galioides*, *Cordaites simplex*, *Alethopteris nervosa*, *Pecopteris arborescens*, *Dadoxylon materiarum*, *Lepidophloios parvus*, and *Sigillaria scutellata.* The total thickness is about 3000 feet. Hence it would seem that in Nova Scotia the upper carboniferous formation is 16,000 feet thick, a thickness which is unparalleled anywhere else. Great as the thickness is, it does not appear to be exaggerated, for upwards of 14,000 feet are exposed in one section, a section which many excellent observers have testified is continuous, and which has long been celebrated as the 'Joggins' section. This section is so instructive that we feel very much disposed to insert here the detailed enumeration of the beds as worked out by Logan, Lyell, and Dawson, but we must content ourselves with the following generalised account of the latter from Dawson's 'Acadian Geology,' 2nd edition:—

Commencing at Seaman's Brook in Mill Cove, and taking Logan's carefully detailed section as our guide, we see in the low cliff, and in the shore-reef, beds of reddish and gray sandstone, alternating with reddish shales or beds of hardened and laminated clay. In a few places we find among these beds layers of gypsum and of a coarse sandy limestone. In several of the gray beds there are fragments of trunks and branches of trees converted into coal, and resembling, what they certainly once were, drift trees imbedded in sand-banks. Associated with these remains we find in four of the beds small quantities of the gray sulphuret and green carbonate of copper, minerals introduced into these beds by waters holding sulphate of copper in solution, which the carbonaceous matter of the fossil wood has deoxidised, and thereby caused its deposition. Such appearances are not infrequent in beds containing fossil plants, but they have not hitherto been found to afford sufficient quantities of copper to be of any practical value. I may also remark here, in connection with the occurrence of fossil plants in gray rather than in red beds, that in the coal formation, as in the modern marshes and peat bogs already described, the presence of vegetable matter has often destroyed the red colour of beds tinged with peroxide of iron, and hence the fossils are in some sense the cause of the gray colour of the beds in which they are found. Beds of the kind just described occupy the shore to a distance equal to 2308 feet, as ascertained by the careful measurement of each bed made by Sir W. Logan. I may remind the reader that as these beds dip to the south-west, we are constantly proceeding from older to newer beds. In the succeeding 3240 feet of beds we find a similar series, with some additional features indicating our approach to the great masses of fossil vegetables entombed in the true coal measures which overlie them. There are here nine seams of coal, all very thin, their total thickness being only ten inches, and under each seam we observe a bed of clay or crumbling argillaceous sandstone, with remains of roots belonging to plants to be noticed hereafter, and which had much to do with the accumulation of the coal. We find also in this thick series of sandstone and shales several bands of hard black limestone, yielding a bituminous and almost animal smell when rubbed or struck, and containing abundance of little diamond-shaped plates with smooth and polished surfaces, which, if we are acquainted with the animals of the coal period, we recognise as the scales of a singular tribe of fish, the ganoids, of which numerous species abounded in the carboniferous period, but which are now represented in America only by the bony pike of the Canadian lakes, and a few other fresh-water fishes. There is also in this part of the section a far greater prevalence of gray sandstones than in the part previously noticed, and in these gray sandstones are immense quantities of fossil plants, most of them trunks of trees confusedly intermingled, and flattened more or less by pressure; others long, cylindrical, reed-like stems (*Calamites*), or immense creeping roots dotted all over with pits, from which their rootlets sprang (*Stigmariæ*). In most of these fossils the bark is converted into hard shining coal, but the wood has decayed away, and the hollow cavity left within the bark has been filled with sand, now hardened into stone like that without. This is a distinct process from petrifaction properly so called, in which the minute cells of the wood become so filled with mineral matter that the minutest parts of the structure are preserved. Some of the gray sandstones of this part of the section are of great thickness, and in them are the most important quarries of the Joggins grindstones, which are exported to all parts of the United States. These grindstones have been formed from beds of sand deposited in such a manner that the grains are of nearly uniform fineness, and they have been cemented together with just sufficient firmness to give cohesion to the stone, and yet to permit its particles to be rubbed off by the contact of steel. A piece of grindstone may appear to be a very simple matter, but it is very rarely that rocks are so constituted as perfectly to fulfil these conditions, and hence the great demand for the Joggins stone. This part of the section suggests many interesting inquiries respecting the mode of formation of some of its beds; but I postpone these until we arrive at those portions which show coal measures properly so called on a somewhat larger scale. Proceeding along the coast, we find that the strata last described are overlaid by a series amounting to 2082 feet in vertical thickness, and differing from the last group of beds in containing fewer gray sandstones, no coal seams or bituminous limestones, and comparatively few fossil plants, and these but imperfectly preserved. This series, then, consists in great part of reddish shales and reddish and gray sandstones. These, and indeed the greater part of the rocks composing the part of the section we have examined, must originally have consisted of beds of reddish sand and mud spread over the bed of that ancient carboniferous sea, once tenanted by the shells of the Napan limestone, much in the same manner that layers of mud are now deposited in the Bay of Fundy. We have now, after passing over beds amounting altogether to the enormous thickness of 7636 feet, reached the commencement of the true coal measures, or that part of the section which was examined in detail by Sir Charles Lyell and the writer in 1852 and 1853. Owing to the comparative softness of the last group described, they have in many places been worn down to the level of the beach, so that they cannot be very distinctly observed. Fortunately, however, just where the section becomes most interesting, the beds rise into a high cliff, and every one can be measured, and its mineral character and fossil contents be observed, by any person who is content to labour diligently, and who is not too apprehensive that he may be buried under the falling cliffs, which, especially in the spring and in stormy weather, often send down very threatening showers of stones and sometimes terrible landslips. Proceeding along the coast from the Joggins mines, we find, toward Ragged Reef, coal measures still exposed, but with fewer and thinner beds of coal. At Ragged Reef there are again very important and valuable beds of grindstone. Beyond this, all the way to Shoulie River, the coast shows sandstones and shales belonging to the upper coal formation. In this we no longer find beds of coal; red sandstones and shales become more abundant, and the gray sandstones become coarse and pebbly, holding rounded fragments of quartz and syenite similar to that of the Cobequid Mountains. Fossils are not abundant, but *Calamites*, *Stigmaria*, *Lepidodendra*, and large petrified trunks of the pine trees of the coal formation, still appear. The general aspect of these beds is to a great extent similar to that of the millstone grit series, and this upper mass of barren coal measures may perhaps be defined to be the weight laid upon the coals to compress them into the required consistency. The whole coal formation and its accompaniments may thus be compared to a huge botanical drying press. The millstone grit is the lower board; the true coal measures represent the plants laid out between leaves of clay and sand instead of paper, and the upper coal formation is the upper board and weight. Towards Shoulie River the dip of the beds diminishes to 5°, and beyond this little stream, which seems to be in the middle of the synclinal, the dip changes to north-east, and the beds are repeated with these north-easterly dips, until at Apple River they finally rest against those old rocks of Cape Chiegnecto, which form the limit of the Cumberland trough in this direction.

The Joggins strata form part of a coal-bearing area which extends in a broad bay opening towards the north-east. This area has only partially been investigated, but it now supports several important mining establishments, more especially in its eastern horn formed by the Sydney coal-field. Between these and Baie des Chaleurs there are considerable developments of upper carboniferous rocks and numerous seams of coal. The area appears to have, at one time, covered a far larger space, for carboniferous rocks occur in the Magdalen Islands and in Newfoundland.

During the last twenty or thirty years large portions of the United States have been minutely surveyed under State patronage, and this has necessarily led to an immense accumulation of details respecting the mode of occurrence of the principal natural useful materials, more especially of coal. The largest coal-field in the world is that forming the great Appalachian basin, the size of which is somewhat greater than Professor Ansted's estimate as given in E. C. Its length from Pennsylvania on the north-east to Alabama on the south-west is about 875 miles, its greatest width is situated in Ohio, and is about 180 miles, and its area, as estimated by Professor Rogers, is nearly 70,000 square miles, or more than one-third of the total known coal area on the globe.

In Pennsylvania the strata are highly undulated, the waves being highest on the south-east margin, and flattening out gradually towards the north-west. Where the waves and the strata are most compressed the anthracitic variety of coal predominates; in passing to the north-west the waves become broader, and the coal semi-bituminous; and still further north-west the undulations die away, and the strata contain seams of bituminous coal. There are very few localities in which both anthracite and bituminous coal are found. The strata which contain the anthracite are far less extensive than those which contain the bituminous coal; the former occupying but a few hundred square miles in Pennsylvania, while the latter are spread over an area of nearly 13,000 square miles. The two series of beds are also for the most part of different ages, that containing anthracite being the older. The upper carboniferous formation of this state is grouped by Professor Rogers into five divisions. (1) The first and lowest is a conglomerate which forms the floor of almost the entire Appalachian basin. It is usually a gray and whitish quartzose conglomerate alternating with yellowish and gray sandstone, and in some localities it comprises a few small seams of coal. In the more eastern or anthracitic portion of the coal-field it consists of large pebbles and coarse sandstones, but further westwards the size of the pebbles is much less. (2) The second division is called the 'Older Coal Measures.' It rests upon, or rather is interblended with, the conglomerate, since their contiguous beds alternate with one another. The lower limit is arbitrarily fixed at the base of the lowest considerable coal seam, and the upper limit is bounded by the 'Mammoth' coal of Pottsville. The strata consist of sandstones, slates, and shales, but the latter two are more sandy in the anthracite region than the argillaceous beds of the bituminous basin; while limestones are never met with in the same district as anthracite. The coal beds are of unusual thickness, some of them being as much as 25 or 30 feet thick. In the western districts the lowest sandstones are saturated with brine, but no such fluid occurs in connection with the anthracitic conglomerates and sandstones. Professor Rogers says the latter were either never impregnated with salt, "or their more crushed and uplifted condition has caused it to filter away to inaccessible depths; or, what is more probable still, the steaming which the anthracite coal measures underwent during their metamorphosis has exhaled the chloride of sodium which they contained." The gradual change in the nature of the strata in their westerly extension is especially noticeable. The shales and sandstones become less sandy, and more minutely comminuted, the fire-clays become more purely argillaceous, and calcareous matter increases towards the west. In the extreme west of Pennsylvania there are usually three bands of limestone, each of which has its peculiar palæontological characters. The thickness of this series is about 600 feet. (3) The third division is called the 'Older Coal Shales,' or 'Lower Barren Group,' and has only been recognised in the western coal-fields. It consists of thick strata of variegated sandstones, associated with red, yellow, and blue marls, and a few beds of argillaceous limestone. The limestones occur near the summit of the group, which is about 500 feet thick, and augment in thickness towards the west. There are no important coal seams. (4) The 'Upper or Newer Coal Measures' have an average thickness of about 200 feet. In the east they consist of argillaceous sandstones, calcareous shales, and thin beds of limestone; but towards the west the arenaceous and argillaceous materials diminish in bulk, while the calcareous members gradually increase until the group consists almost entirely of calcareous shales and limestones in Ohio. This group comprises the Pittsburg and Waynesburg coal seams. (5) The 'Upper or Newer Coal Shales, or Upper Barren Group' is known only in the south-west corner of Pennsylvania, and has a thickness of somewhat less than 1000 feet. There are a few unimportant seams of coal, and a number of limestones, but the great bulk is composed of sandy shales, and micaceous sandstones.

The number of workable seams of coal is larger in Pennsylvania than in any other of the United States; and, as a general rule, the aggregate thickness of the coal measures lessens, and the number of the coal seams become fewer, as we advance towards the south or towards the west. The principal seam in Pennsylvania is the 'Pittsburg coal,' which is not only remarkable for its thickness, but also for the immense area over which it has been detected. It appears to have an elliptical out-crop, and to have a superficies of 14,000 square miles. It is remarkably uniform in its character, but its thickness varies from 15 feet in south-west Pennsylvania to 3 feet in its southernmost range. The higher beds in Pennsylvania are more uniform and constant than the lower, a character which Professor Rogers observes is probably connected with a more marine or less littoral origin, as evinced in a larger proportion of limestones and other oceanic deposits, in a finer state of comminution of the land-derived sediments, and especially in a greater abundance of marine forms among the fossils.

The Michigan coal-field occupies the central counties of that state to the extent of between 12,000 and 15,000 square miles; but little is known respecting it, owing to its being generally concealed by drift deposits and dense forests. It was, as is believed, originally continuous with the great basins farther south.

The Illinois coal-field forms a somewhat oval patch, the long axis of which measures 275 miles, and the short one about 200. The total area is estimated at not less than 51,000 square miles. The floor of the basin is undulated by minor folds, in the valleys between which the coal-bearing strata were deposited. According to Dr. Norwood the strata have been displaced and eroded since the commencement of the coal measure period, so that the upper portion of these is frequently unconformable to the lower portion.

In the Western Kentucky coal-field there are two sets of coal measures, which are separated by a sandstone, locally termed the 'Anvil Rock.' The lower coal measures are 1029 feet thick, and contain nine workable coal seams; the upper coal measures are about 2400 feet thick, and embrace eight workable coal seams. The aggregate thickness of all the coals is estimated at 40 feet. This field also has an undulated structure.

The Iowa and Missouri coal-field stretches from Missouri through Iowa into Kansas, and perhaps farther west. The dip is generally westerly, and in the direction of the dip there follows a series of higher strata which have been identified as of Permian age. In Missouri the coal measures occupy 26,887 square miles, and are divisible into three groups. The lower series has a thickness near the mouth of the La Mine of 150 feet, and includes six coal-seams; the lowest is 3 feet thick; the fifth from the bottom 6 feet, and the others are of inconsiderable dimensions. The associated strata are mostly bituminous shales. The middle coal measures have an average thickness of about 200 feet, and consist of brown and gray sandstones, blue and yellow shales, and compact blue and buff limestones. There are also a few thin seams of bituminous coal. The upper coal measures are about 300 feet thick. They contain no workable coal seams, but numerous thin bands; and consist of blue and gray shales, gray and buff limestones, and soft shaly sandstones, all the strata being more or less bituminous.

The Iowa coal measures are an extension of those of Illinois, the present separation being due to the formation of the Mississippi Valley, which has been excavated out of the carboniferous and subjacent rocks. In this state also there are facts which point to an unconformability between the upper and lower carboniferous series; as also to extensive alterations of level and denudations of the beds in the interval between their deposition. Thus, in traversing the district from north to south, the coal measures are observed to rest transgressively, first upon pre-carboniferous strata, and then upon each of the members of the lower carboniferous series, from the Burlington limestone at the base to the Kaskaskia limestone at the summit. In addition to these, there are other irregularities, an account of which we quote from Hall and Whitney's 'Report on the Geology of Iowa,' vol. i., because they afford evidence of some of the caves, and possibly river valleys, which were formed during the carboniferous period:—"Beyond these irregularities of surface, there are cavities in the limestone of the Upper Helderberg period, which are filled with greenish-gray clay, like the under-clay of coal seams. These are so numerous and decided in their character, as to leave no doubt that they are ancient enlarged fissures and cavernous openings made by running water, and afterwards filled with clay during the deposition of the coal measures. One of the most remarkable exhibitions of this kind occurs in the vertical face of a quarry at Rock Island. The strata consist of shales and shaly limestones of the Hamilton group, and some beds of the limestone of the Upper Helderberg. The surface of the rock beneath the superincumbent soil presents a depression which deepens into a broad funnel-shaped cavity gradually narrowing below till within ten feet of the bottom, when it spreads out on one side with an irregularly arching roof and an unequal floor. It is filled from top to bottom with hard clay, similar to the under-clay of coal seams. At the top of the funnel this clay is of a reddish brown colour, due to the infiltration from the ferruginous soil above; but below it soon becomes of the ordinary gray colour. The laminations of this clay conform to the curvatures and irregularities of the roof and floor of the ancient cavern, and exhibit the appearance of having flowed in while in a semi-fluid condition, while the hydrostatic pressure of the mass above, acting through the deep funnel, had forced the soft mass against the walls and roof of the cavity, causing it to assume in its lamination the same contour. . . . The conclusion seems, therefore, irresistible that subsequent to the uplifting of these rocks, the denudation of their surface and the wearing into caverns, the materials of the coal measures were deposited, filling these cavities, and resting in successive members upon the surface of the older rocks. If anything were wanting to complete the chain of facts and carry the most conclusive evidence, it is found in a section near Iowa city, where, in a cliff of limestone of the Hamilton group, we have the following phenomena :—Between beds of nearly horizontal limestone appears a black band extending thirty or forty feet ; this consists of black carbonaceous mud, the upper part having the character of cannel coal and the lower part that of a slaty carbonaceous shale. Beneath this, and less extended, a thicker layer of clay, precisely like that which is found in the cavities before described and of the character of underclay, fills the upper and broader part of the cavity ; while below this, and occupying the broadest parts, is a coarse sandstone, which follows, in its lines of lamination, the curvature of the limestone upon which it lies. Here we have all the phenomena attending a true coal measure seam of coal ; the sandstone, the underclay, and the coal seam resting upon it ; and, to complete the analogy, the slaty portion of the seam contains fish-teeth of carboniferous character. All this is enclosed in limestone, which, in the State of New York, lies at a depth of more than five thousand feet below the coal measures. The explanation is obvious. This instance corresponds with the preceding, being only a little more complete in its series of members, while the aperture of admission is not visible in the exposure. The coarse and fine sand were first transported, and, entering some fissure in the rock, continued in deposition in the cavity while a bed of similar sandstone was being formed outside and upon the bottom of the sea. This ceased, and then came the clay, which was continued in like manner while the underclay of an exterior coal bed was in process of deposition. Lastly, the carboniferous mud derived from the materials of a coal seam was filtered through the fissure, filling the remaining space, and spreading out in the narrow seam beyond. There is no mingling of the materials as if resulting from the breaking up of a coal seam at a later and modern period. Every part is as distinct as in the coal measures elsewhere ; and this could only have resulted from a participation in the causes then operating to produce those extensive beds of sand, clay, shale, and coal, which make up the coal measures." The same author mentions another section near the same city in which a carboniferous sandstone, horizontally stratified, lies in the midst of a Devonian limestone, which is also approximately horizontal. There is nothing to show that a fault exists ; but the facts indicate that the sandstone is situated in a valley denuded out of the limestone.

Plants may be distinguished as belonging to two great groups, the spore-bearers or Cryptogams, and the seed-producers or Phanerogams. The former embrace the flowerless plants, which may be grouped as Thallogens and Acrogens. The former include all the flowering plants, and may be grouped into the three divisions of the Gymnosperms, the Endogens, and the Exogens.

The Thallogens include the sea-weeds, the mushrooms, and the lichens, of which very few traces have been found in the coal measures. The Acrogens comprise the lycopods, the mosses, and the ferns, and were, to judge from their relics, remarkably abundant, although no positive evidence appears to have been acquired respecting one entire group, viz., that of mosses. Lesquereux says the genus *Sphagnum* is present in the coal of America, but his opinion is founded upon a few obscure impressions. This absence, or at any rate rarity, of a group of plants which plays so important a part in the formation of peat, the modern analogue of coal, is a remarkable fact. There is another family, viz., the *Characeæ*, so characteristic of the stagnant pools and slowly flowing waters of the present day, whose absence from the coal measures may be especially referred to. The *Equisetaceæ*, or Horse-tail family, is the first we come to in ascending order, which affords unquestionable carboniferous representatives. The genera included in it by Dr. Dawson are *Calamites*, *Equisetites*, *Asterophyllites*, *Annularia*, *Sphenophyllum*, and *Pinnularia*. Of *Calamites* he has discovered and figured several entire specimens ; and from the examination of these he has ascertained that the stem was hollow, divided at the joints by transverse diaphragms, and not surrounded either by true wood or bark. The part which has usually been regarded as bark is only a thin external shell of fibres and scalariform vessels. The species formed dense brakes in moist localities subject to frequent inundations ; and eight or nine of them have been found in Nova Scotia. One of the commonest is *C. Suckovii;* besides which he enumerates *C. Cistii*, *C. cannæformis*, *C. ramosus*, *C. Voltzii*, *C. dubius*, *C. Nova-Scotica*, *C. nodosus*, and *C. arenaceus* (?). Lesquereux records 11 species from Pennsylvania, viz., *C. decoratus; C. Suckovii*, which forms a forest round Carbondale ; *C. ramosus; C. cruciatus; C. undulatus; C. Cistii*, of which one specimen only has been found, so that it would seem to have been far more abundant in Nova Scotia than in Pennsylvania ; *C. dubius; C. cannæformis; C. bistriatus; C. disjunctus; C. approximatus*, a common species in Pennsylvania, but not mentioned by Dr. Dawson in his list of Nova Scotian species. In the Saarbrück coal-field there occur *C. cannæformis*, *C. Suckovii*, *C. Cistii*, and *C. cruciatus;* in that near Aachen there occur *C. cannæformis*, *C. Suckovii*, *C. approximatus:* these three species also occur in the Westphalian basin, along with *C. Roemeri* and *C. Cistii;* and four of these, the exception being *C. Roemeri*, range to Hanover, Bohemia, France, Sardinia, and Russia. *Equisetites* includes plants more like the modern horsetails than *Calamites;* but very little seems to be known respecting it. Dawson describes one species from Nova Scotia ; and one or two are mentioned as being found in many coal-fields, but most of the species assigned to this genus do not belong to it. *Asterophyllites* resembles *Calamites* in its ribbed and jointed stem, in its whorls of leaves or branchlets, but differs from it in that the leaves have distinct middle ribs ; it resembles *Calamodendron* in having a stout internal cylinder. Five species occur in Nova Scotia, viz., *A. foliosa*, *A. grandis* (?), *A. trinervis*, *A. curta*, and *A. sp.* not determined. Lesquereux describes nine Pennsylvanian species, viz., *A. equisetiformis*, *A. foliosa*, *A. crassicaulis*, *A. ovalis*, *A. sublævis*, *A. tuberculata*, *A. lanceolata*, *A. aperta*, and *A. Brardii*. Germany has afforded *A. rigida*, *A. longifolia*, *A. equisetiformis*, *A. grandis*, *A. foliosa;* while only a few species, including *A. rigida*, are recorded from Russia. *Annularia* is probably the same as *Asterophyllites*. Two species, *A. sphenophylloides* and *A. equisetiformis*, occur in Nova Scotia ; three, or perhaps four, in Pennsylvania, *A. minuta*, *A. fertilis*, *A. longifolia*, and *A. sphenophylloides;* four in Germany, *A. longifolia*, *A. sphenophylloides*, *A. microphylla*, *A. radiata;* two in France, *A. longifolia* and *A. sphenophylloides;* and the last-mentioned two are probably also found in Russia. *Sphenophyllum*, like many other genera of this period, is a comprehensive type, that is, it embraces characters which are now distributed amongst several families. Dawson believes the species were cryptogamous plants which had a habit of growth like that of the *Equisetaceæ*, leaves like those of ferns, and fructification and structure like those of the *Lycopodiaceæ*. There are five Nova Scotian species, *S. emarginatum*, *S. longifolium*, *S. saxifragæfolium*, *S. Schlotheimii*, *S. erosum*. Lesquereux gives five Pennsylvanian species, *S. Schlotheimii*, *S. emarginatum*, *S. filiculme*, *S. trifoliatum*, and *S. oblongifolium*. The German species are *S. emarginatum*, *S. saxifragæfolium*, *S. oblongifolium*, *S. angustifolium;* the French species are *S. emarginatum*, *S. saxifragæfolium*, and *S. longifolium;* and the only species mentioned from Russia by Eichwald is *S. Schlotheimii*, which, however, appears to be either *S. emarginatum* or *S. saxifragæfolium*. The species of *Pinnularia* are believed to be simply the roots of some of the above-mentioned plants.

The next family we have to consider is the *Lycopodiaceæ*, which constitutes one of the most prominent features of the coal flora, being represented by the genera *Lepidodendron*, *Lepidophloios*, and *Cordaites;* there are also other generic terms applied to fragments of plants of this family, whose precise affinities are unknown. Thus the rounded spore cases are called *Sporangites;* the cones which held the spore cases, *Lepidostrobus;* the leaves, *Lepidophyllum;* and the roots probably help to swell the muster-roll of the heterogeneous assemblage called *Stigmaria*. Dr. Dawson supports the lycopodiaceous affinities of *Lepidodendron*, and maintains that the dichotomous ramification, the spore—not seed—bearing cones, and the internal structure, forbid its being associated with the pine tribe. All the genera are abundant in individuals, and many coal seams are largely composed of their trunks, leaves or disaggregated tissues. The Nova Scotian members of this family include the following :—*Lepidodendron corrugatum*, abundant in the coal measures of the lower carboniferous series ; *L. pictoense*, *L. rimosum*, *L. dichotomum*, *L. decurtatum*, *L. undulatum*, *L. dilatatum*, *L. binerve*, *L. tumidum*, *L. gracile*, *L. elegans*, *L. plumarium*, *L. selaginoides*, *L. Harcourtii*, *L. aculeatum*, *L. plicatum*, *L. personatum*, and *L. clypeatum;* *Lepidostrobus variabilis*, *L. squamosus*, *L. longifolius*, and *L. trigonolepis;* *Lepidophyllum lanceolatum*, *L. trinerve*, *L. majus*, and *L.*

intermedium; Lepidophloios acadianus, L. prominulus, L. parvus, L. platystigma, and *L. tetragonus; Knorria Sellonii; Cordaites borassifolia,* very abundant; *C. simplex; Sporangites papillata.* The Pennsylvanian species enumerated by Lesquereux are *Lepidodendron aculeatum, L. rugosum, L. crenatum, L. obovatum, L. modulatum, L. giganteum, L. vestitum, L. conicum, L. oculatum, L. distans, L. rimosum, L. obtusum, L. carinatum, L. clypeatum, L. sigillarioides, L. Mieleckii;* or sixteen species in all of this genus, some of which are probably only synonyms founded upon different degrees of imperfection of preservation of the same species of trunk: *Lepidophyllum acuminatum, L. obtusum, L. lanceolatum, L. affine, L. hastatum, L. brevifolium, L. plicatum, L. lineare; Lepidostrobus ornatus, L. variabilis, L. pinaster; Cordaites borassifolia.* The same author also mentions a number of species of *Cardiocarpon, Rhabdocarpos, Trigonocarpon, Carpolithes* and *Cyperites,* some of which probably appertain to this family. The German species include *Lepidodendron denticulum, L. elongatum, L. primævum, L. lepidostachyum, L. macrophyllum, L. taxinum, L. dichotomum, L. elegans, L. rimosum, L. aculeatum, L. laricinum, L. caudatum; Lepidostrobus variabilis; Lepidophyllum majus; Lepidophloios lepidophyllaceum; Cordaites principalis; C. borassifolia;* and a number of species assigned to *Rhabdocarpos, Cardiocarpon, Trigonocarpon, Ulodendron, Halonia, Knorria,* &c. The French species number about seven in Geinitz's 'Die Steinkohlen,' and are named *Lycopodites foliiformis; Lepidophyllum lanceolatum, L. caricinum; Lepidodendron gracile, L. Lorierei, L. erectum, L. laricinum.* The Russian species, according to Russian palæontologists, are twenty-four in number, but the specimens found have not been well determined, and do not, probably, represent half this number of species.

The ferns, or *Filices,* of the coal measures are still classified by whatever characters can be detected, which are seldom those which enable the botanist to arrange them in natural genera; and some of them are known not to be applicable to the distinction of natural groups in the living forms. One illustration of this occurs in the genera *Cyclopteris* and *Neuropteris,* which Lesquereux has shown to be based on the fronds of the same kind of fern in different stages of development. The cyclopteroid fronds represent the earliest stage; and the neuropteroid the adult form. The great variation in the same species is thus pointed out by him. "The essential character," he says, "of this variable species [*Neuropteris hirsuta*] was first observed by Mr. Bunbury, and mentioned in his description of the fossil plants of Nova Scotia, viz., the short hairs scattered on the surface of the leaves. We have scarcely seen a well-preserved specimen on which these hairs were not observable with a lens. They appear, nevertheless, to have been brittle, and easily falling off; for sometimes there are only a few of them left on some part of a leaf, and sometimes they are numerous on the whole surface. The species is the most common of all in the coal-fields of Pennsylvania, from the lowest veins to the highest; and we have frequently had an opportunity of studying it where its remains were the only ones preserved. The short petioles by which the leaflets are attached to the common rachis, have a peculiar structure. Being enlarged on the stem and pointed above they stand on the rachis, ordinarily deprived of its leaves, exactly like thorns. The point of attachment of the leaves was so slender and brittle that we very seldom find any of the pinnules attached to the stem. We have seen them in this state only once or twice among many thousand specimens that have come under examination. It is easy to follow the mutations of the forms of the leaves and leaflets [in the figures given by Lesquereux]. The most remarkable of these transformations occur in some of the upper leaflets. Near the summit of the pinnæ, the pinnules become simple, narrowly convolute (in which case they belong to *Neuropteris angustifolia,* Brongt.), and there they are sometimes cut in many lobes, either to the base or to the middle, preserving ordinarily a medial nerve in each division. The basilar leaflets, also, are sometimes diversely lobed, but they preserve always the flabelliform nerves diverging from the base, without any trace of a medial nerve. By following the series of transformations it is easy to identify the genus *Neuropteris* with *Cyclopteris.*" Dawson recognises 15 principal genera in Nova Scotia, viz., *Cyclopteris, Neuropteris, Odontopteris, Dictyopteris, Lonchopteris, Sphenopteris, Phyllopteris, Alethopteris, Pecopteris, Beinertia, Hymenophyllites, Palæopteris, Caulopteris, Psaronius,* and *Megaphyton.* Short descriptions of most of these have already been given in E.C., and of those which are undescribed we append notices here. *Dictyopteris* resembles *Neuropteris* in the form of the pinnules, but differs in the reticulated arrangement of the veins. *Phyllopteris* has pinnate fronds, long lanceolate pinnules having a well-defined midrib from which the nerves proceed obliquely to the margin. *Alethopteris* includes some of the most common carboniferous ferns. The fronds are pinnate; the pinnules often long, narrow, and more or less produced along the petiole, to which they adhere by their whole base. It closely resembles *Pecopteris,* but may be distinguished by the confluent bases of the pinnules, and by the rectangular disposition of the nerves relatively to the midrib. From this it will be seen that the *Pecopteris lonchitica* figured in E. C. vol. ii. col. 32, really belongs to this genus. *Beinertia* embraces the *Pecopteris*-like species in which the nerves are flexuous, branching, and parallel to the edge of the pinnule near their extremities. *Hymenophyllites* includes ferns like *Sphenopteris,* in which the marginal lobes have only one nerve each. *Palæopteris, Caulopteris, Psaronius,* and *Megaphyton,* are tree ferns, distinguished by the shape or arrangement of the leaf-scars. In *Palæopteris* they are transversely oval, in *Caulopteris* elongate, in *Psaronius* they are surrounded by aërial roots, and in *Megaphyton* they are arranged in two rows, one on each side of the stem. This last-mentioned genus is not usually placed amongst ferns, and Dr. Dawson gives the following reasons for assigning it this position:—"Their thick stems, marked with linear scars, and having two rows of large depressed areoles on the sides, suggest no affinities to any known plants. They are usually ranked with *Lepidodendron* and *Ulodendron,* but sometimes, and probably with greater reason, are regarded as allied to tree ferns. At the Joggins a very fine species (*M. magnificum*) has been found; and at Sydney a smaller species (*M. humile*); but both are rare, and not well preserved. If the large scars bore cones, and the smaller bore leaves, then, as Brongniart remarks, the plant would much resemble *Lepidophloios;* they are reniform or oval, and resemble those of tree ferns, for which reason they may be regarded as more probably leaf scars; and in that case the smaller linear scars would indicate ramenta, or small aërial roots. Further, the plant described by Corda as *Zippea disticha,* is evidently a *Megaphyton,* and the structure of that species is plainly that of a tree fern of somewhat peculiar type. On these grounds I incline to the opinion of Geinitz, that these curious trees were allied to ferns, and bore two rows of large fronds, the trunks being covered with coarse hairs or small aërial roots. At one time I was disposed to suspect that they may have crept along the ground; but a specimen from Sydney shows the leaf-stalks proceeding from the stem at an angle so acute that the stem must, I think, have been erect. From the appearance of the scars it is probable that only a pair of fronds were borne at one time at the top of the stem, and if these were broad and spreading, it would be a very graceful plant."

In order to show that the resemblance between the ferns of distant regions is considerable, we have drawn up the subjoined table; but it should be looked upon rather as a list of different forms and shapes of fronds and pinnules than of species.

	Nova Scotia.	Pennsylvania.	Western United States.	Germany.	France.	Russia.
Cyclopteris heterophylla	*					
C. acadica (lower carboniferous)	*					
C. oblongifolia	*					
C. obliqua	*	*	—	*	*	
C. ingens	*					
C. oblata	*					
C. fimbriata	*	*	*			
C. hispida	*					
C. antiqua (lower carboniferous)	*					
C. flabellata	—	—	*	*		
C. laciniata	—	*				
C. undans	—	*				
C. elegans	—	*				
C. orbicularis	—	*				
C. Germari	—	*				
C. tenera	—	—	—	*		
C. rhomboidea	—	—	—	*		
C. nana	—	—	—	—	—	*
C. alula	—	—	—	—	—	*
Neuropteris ravinervis	*	*				
N. perelegans	*					
N. cordata (or hirsuta of Lesquereux)	*	*	—	*	*	
N. Voltzii	*					
N. gigantea	*	*	—	*	*	*
N. flexuosa	*	*	—	*	*	
N. heterophylla	*	*	—	*	*	

	Nova Scotia.	Pennsylvania.	Western United States.	Germany.	France.	Russia.
Neuropteris Loshii	*	*	—	*	*	
N. acutifolia	*	—	—	*		
N. conjugata	*					
N. attenuata	*					
N. dentata	*	*				
N. Soretii	*	—	—	—	*	
N. auriculata	*	—	—	*	*	
N. cyclopteroides	*					
N. Rogeri	—	*				
N. Clarksoni	—	*				
N. fissa	—	*				
N. smilacifolia	—	*				
N. plicata	—	*	—	*		
N. rotundifolia	—	*	—	*	*	
N. tenuifolia	—	*	—	*	*	*
N. Grangeri	—	*				
N. Cistii	—	*				
N. delicatula	—	*				
N. Villiersi	—	*	—	—	*	
N. gibbosa	—	*				
N. crenulata	—	*	—	*		
N. tenuinervis	—	*				
N. Desorii	—	*				
N. minor	—	*				
N. Moorii	—	*				
N. adiantites	—	*				
N. mirabilis	—	—	—	*		
N. regina	—	—	—	*		
N. densifolia	—	—	—	*		
N. coriacea	—	—	—	*		
N. rubescens	—	—	—	*		
N. bohemica	—	—	—	*		
N. Leberti	—	—	—	—	*	
N. Escheri	—	—	—	—	*	
N. microphylla	—	—	—	—	*	
Odontopteris Schlotheimii	*	*	—	*		
O. subcuneata	*					
O. squamosa	—	*				
O. crenulata	—	*				
O. Brardii	—	* ?	—	—	*	
O. dubia	—	*				
O. hercynica	—	—	—	*		
O. Schützei	—	—	—	*		
O. obtusiloba	—	—	—	*		
O. britannica	—	—	—	*		
O. Reichiana	—	—	—	*		
O. minor	—	—	—	—	*	
O. alpina	—	—	—	—	*	
Dictyopteris obliqua	*	*	*			
D. Brongniarti	—	—	—	*		
D. neuropteroides	—	—	—	*		
Lonchopteris tenuis	*					
L. rugosa	—	—	—	*	*	
L. Roehli	—	—	—	*		
Sphenopteris nunda	*					
S. hymenophylloides	*					
S. latior	*					
S. decipiens	*	*	—	*		
S. gracilis	*					
S. artimisiæfolia	*	*	—	*		
S. canadensis	*					
S. Lesquereuxii	*	*				
S. microloba	*					
S. obtusiloba	*	—	—	*		
S. Darallia	—	*				
S. tenella	—	*				
S. Gravenhorstii	—	*	—	*		
S. Dubuissonii	—	*	—	—	*	
S. abbreviata	—	*				
S. intermedia	—	*				
S. flagellaris	—	*				
S. plicata	—	*				
S. latifolia	—	*	—	*		
S. acuta	—	*	—	*		
S. glandulosa	—	*				
S. polyphylla	—	*				
S. Newberryi	—	*				
S. squamosa	—	*				
S. cristata	—	—	—	*	*	
S. integra	—	—	—	*		
S. irregularis	—	—	—	*	*	
S. Hœninghausi	—	—	—	*	*	
S. muricata	—	—	—	*		
S. Schlotheimii	—	—	—	*		
S. formosa	—	—	—	*		
S. delicatula	—	—	—	*		
S. distans	—	—	—	*		
S. Bronni	—	—	—	*		
S. coralloides	—	—	—	*		

	Nova Scotia.	Pennsylvania.	Western United States.	Germany.	France.	Russia.
Sphenopteris linearis	—	—	—	*		
S. elegans	—	—	—	*		
S. meifolia	—	—	—	*		
S. lanceolata	—	—	—	*		
S. Gutbieri	—	—	—	*		
S. debilis	—	—	—	*		
S. tenuissima	—	—	—	*		
S. acutifolia	—	—	—	*		
S. tenuifolia	—	—	—	—	*	
S. Virleti	—	—	—	—	*	
S. acutiloba	—	—	—	—	*	
S. imbricata	—	—	—	—	—	*
S. nota	—	—	—	—	—	*
S. crithmifolia	—	—	—	—	—	*
S. rutæfolia	—	—	—	—	—	*
Phyllopteris (?) antiqua	*					
Alethopteris lonchitica	*	*	—	*	*	*
A. heterophylla (lower carboniferous)	*					
A. Grandini	*	—	—	*		
A. nervosa	*	*	—	*	*	
A. muricata	*	*				
A. pteroides	*	—	—	*	*	
A. Serlii	*	*	—	*	*	
A. grandis	*					
A. pennsylvanica	—	*				
A. aquilina	—	*	—	*	—	*
A. urophylla	—	*	—	*		
A. marginata	—	*	—	*		
A. distans	—	*				
A. obscura	—	*				
A. serrula	—	*				
A. lævis	—	*				
A. pseudo-Bucklandi	—	—	—	*		
A. longifolia	—	—	—	*		
A. alethopteroides	—	—	—	*		
Pecopteris arborescens	*	*	—	*	*	
P. abbreviata	*	*	—	*		
P. rigida	*					
P. unita	*	*	—	*	*	
P. plumosa	*	*	—	*	*	
P. polymorpha	*	*				
P. acuta	*	—	—	*	*	
P. longifolia	*					
P. taeniopteroides	*					
P. cyathea	*	*				
P. æqualis	*	—	—	—	*	
P. Sillimani	*	*				
P. villosa	*	—	—	*		
P. Bucklandi	*					
P. oreopteroides	*	*	—	*	*	
P. decurrens	*	*	—	*		
P. Pluckenetii	*					
P. Cistii	—	*				
P. velutina	—	*				
P. ovata	—	*				
P. notata	—	*				
P. pusilla	—	*				
P. arguta	—	*	—	*	*	
P. concinna	—	*				
P. pennæformis	—	*	—	*	*	
P. Loshii	—	*				
P. incompleta	—	*				
P. Miltoni	—	—	—	*	*	
P. Candolleanus	—	—	—	*		
P. dentatus	—	—	—	*	*	
P. subnervosa	—	—	—	*		
P. setosa	—	—	—	*		
P. mucronata	—	—	—	*		
P. hemiteloides	—	—	—	—	*	
P. asper	—	—	—	—	*	
P. Bioti	—	—	—	—	*	
P. punctulatus	—	—	—	—	*	
P. marginata	—	—	—	—	*	
P. Lemuriana	—	—	—	—	*	
P. Mantelli	—	—	—	—	—	*
Beinertia Goepperti	*					
Hymenophyllites pentadactylus	*					
H. Hildreti	—	*				
H. capillaris	—	*				
H. furcatus	—	—	—	*	*	
H. alatus	—	—	—	*		
H. stipulatus	—	—	—	*		
H. dissectus	—	—	—	—	*	
Palæopteris Harttii	*					
P. acadica	*					
Caulopteris sp.	*					
C. punctata	—	*				
C. gigantea	—	*	—	*		
C. Cistii	—	*				

	Nova Scotia.	Pennsylvania.	Western United States.	Germany.	France.	Russia.
Caulopteris peltigera	—	—	—	•	•	
Psaronius (undet. species)	•	•	•			
P. angulatus	—	—	—	—	—	•
P. (five sp.)	—	—	—	•		
Megaphyton magnificum	•					
M. humile	•					
M. discretum	—	•				
M. approximatum	—	—	—	•		
M. distans	—	—	—	•		
M. majus	—	—	—	•		
M. foveolatum	—	—	—	—	—	•

In addition to these there are a number of species belonging to genera whose affinity is very doubtful, such as *Crematopteris*, *Scolopendrites*, *Schizopteris*, *Caunophyllites*, *Zippea*, *Tempskya*, *Selenopteris*, *Gyropteris*, *Anachoropteris*, *Diplophacelus*, *Chorionopteris*, &c.

The *Marsileaceæ*, or pepper-worts, which, at the present day, chiefly frequent moist ditches and inundated localities are not represented by any known species in the coal flora. Ludwig records *Pilularia principalis* from Russia; but the correct determination of this species seems doubtful.

In the above summary it will be seen that great gaps occur in the cryptogams of this period, which were chiefly represented by one or two groups. These gaps are due either to the imperfect state of our knowledge or to the circumstance that the missing groups were not developed at this period. When, however, we examine what is known of the Phanerogams, or flowering plants, the missing groups are found to be far more numerous actually and proportionally; for of about sixty orders not more than three are known to have been then in existence. There would appear to have been no grasses, sedges, or rushes, although the latter two prevail now in marshes and swamps; indeed very few monocotyledonous species have been discovered, while of the dicotyledons the gymnosperms only have yielded remains. This statement must be accepted with some reserve, for Geinitz mentions *Graminites Feistmanteli*, which he stated, in 1865, was the first species of grass found in the coal formation: it was obtained from the Radnitz coal-field. The few monocotyledons are mostly referred to the Palm tribe, and consist of *Palmacites crassinervius*, *Gulielmites clypeiformis*, *G. umbonata*, *Flabellaria Sternbergi*, *Fasciculites carbonigenus*, *F. leptoxylon.*

The following list will indicate the degree of resemblance between the phanerogamous floras of America and Europe:—

	Nova Scotia.	Pennsylvania.	Western United States.	Germany.	France.	Russia.
Dadoxylon Acadianum	•					
D. materiarum	•					
D. antiquius (lower carboniferous)	•					
D. annulatum	•					
D. (Pinites) densifolius	—	—	—	•		
D. („) Mercklingi	—	—	—	—	—	•
Araucarites gracilis	•					
A. Cordai	—	—	—	•		
A. Tschihatscheffianus	—	—	—	—	—	•
Sigillaria elegans	•	•	—	•	•	
S. tessellata	•	•	—	•	•	
S. scutellata	•	•	—	•	•	
S. Schlotheimiana	•	—	—	•		
S. Saullii	•					
S. Brownii	•					
S. reniformis	•	•	—	•	•	
S. lævigata	•	•	—	•	•	
S. planicosta	•					
S. catenoides	•					
S. striata	•	—	—	•		
S. Menardi	•	•	—	•		
S. sydnensis	•					
S. organa	•	—	—	•		
S. elongata	•	•	—	•		
S. flexuosa	•					
S. pachyderma	•	—	—	•		
S. bretonensis	•					

	Nova Scotia.	Pennsylvania.	Western United States.	Germany.	France.	Russia.
Sigillaria eminens	•					
S. Dournasii	•	—	—	•	•	
S. Knorrii	•	—	—	•		
S. lepidodendrifolia	—	•	—	•	•	
S. sculpta	—	•				
S. obliqua	—	•				
S. fissa	—	•				
S. dilatata	—	•				
S. Schimperi	—	•				
S. stellata	—	•				
S. Brardii	—	•	—	•	•	
S. Defrancii	—	•				
S. Serlii	—	•	—	•		
S. Brochantii	—	•	—	•		
S. alveolaris	—	•	—	•		
S. Sillimanni	—	•	—	•		
S. oculata	—	•	—	•		
S. polita	—	•				
S. dubia	—	•				
S. obovata	—	•				
S. rugosa	—	•	—	•		
S. alternans	—	•	—	•		
S catenulata	—	•				
S. discoidea	—	•				
S. Preuiana	—	—	—	•		
S. carinata	—	—	—	•		
S. subsulcata	—	—	—	•		
S. distans	—	—	—	•		
S. Brongniarti	—	—	—	•		
S. rhomboidea	—	—	—	•	•	
S. rimosa	—	—	—	•		
S. æquabilis	—	—	—	•		
S. ornata	—	—	—	•		
S. pyriformis	—	—	—	•		
S. mamillaris	—	—	—	•	•	
S. Graeseri	—	—	—	•		
S. Utschneideri	—	—	—	•		
S. subrotunda	—	—	—	•		
S. aspera	—	—	—	•		
S. coarctata	—	—	—	•		
S. notata	—	—	—	•	•	
S. elliptica	—	—	—	•	•	•
S. regmostigma	—	—	—	•		
S. orbicularis	—	—	—	•		
S. intermedia	—	—	—	•	•	•
S. Cortei	—	—	—	•		
S. Deutschiana	—	—	—	•		
S. Polleriana	—	—	—	•		
S. cyclostigma	—	—	—	•	•	
S. transversalis	—	—	—	•		
S. minuta	—	—	—	•		
S. pulchella	—	—	—	•		
S. muralis	—	—	—	•		
S. ichthyolepis	—	—	—	•		
S. rhytidolepis	—	—	—	•		
S. Feistmanteli	—	—	—	•		
S. diploderma	—	—	—	•		
S. venosa	—	—	—	—	•	
S. minima	—	—	—	—	•	
S. Boblagi	—	—	—	—	•	
S. cuspidata	—	—	—	—	•	
S. Candolli	—	—	—	—	•	
S. Davreuxi	—	—	—	—	•	
S. Guerangeri	—	—	—	—	•	
S. hippocrepis	—	—	—	—	•	
S. interrupta	—	—	—	—	—	•
S. nodulosa	—	—	—	—	—	•
Syringodendron, species (lower carboniferous)	•					
S. pachyderma	—	•	—	•		
S. cyclostegia	—	•				
Stigmaria, numerous species	•	•		•	•	•
Calamodendron approximatum	•	•				
C. obscurum	•					

Numerous fragments have been dignified with generic names, such as *Trigonocarpon*, *Rhabdocarpos*, *Sternbergia*, *Cyperites*, &c., &c. The most important of all these trees in the production of coal were the species of *Sigillaria*, of a common form of which, *S. Brownii*, we append a sketch as given by Dr. Dawson in his work on the geology of Nova Scotia. "Imagine," he says, "a tall cylindrical trunk, spreading at the base, and marked by perpendicular rounded ribs, giving it the appearance of a clustered or fluted column. These ribs are marked by rows of spots or pits left by fallen leaves, and towards the base they disappear, and the bark becomes rough and uneven, but still retains obscure indications of the leaf-scars, widened transversely by the expansion of the stem. At the base the trunk spreads into roots, but with a regular bifurcation quite unexampled in modern trees, and the thick cylindrical roots are marked with round sunken pits or areoles, from which spread long cylindrical rootlets. These roots are the so-called *Stigmariæ*, at one time regarded as independent plants; and, as the reader may have already observed, remarkable for their constant presence in the underclays of the coal-beds. Casting our eyes upward, we find the pillar-like trunk either quite simple or spreading, by regular bifurcation, into a few thick branches, covered with long narrow leaves looking like grass, or, more exactly, like pine-leaves greatly increased in size; or, more exactly still, like single leaflets of the leaves of Cycads. Near the top, if the plant were in fruit, we might observe long catkins of obscure flowers, or strings of large nut-like seeds borne in rings or whorls encircling the stem. If we could apply a woodman's axe to a *Sigillaria* we should find it very different in structure from that of our ordinary trees, but not unlike that of the Cycads or false sago-plants of the tropics. A lumberman would probably regard it as a tree nearly all bark, with only a slender core of wood in the middle; and, botanically, he would be very near the truth. The outer rind or bark of the tree was very hard. Within this was a very thick inner bark, partly composed of a soft corky cellular tissue, and partly of long tough fibrous cells, like those of the bark of the cedar. This occupied the greater part of the stem even in old trees four or five feet in diameter. Within this we would find a comparatively small cylinder, not unlike pine in its appearance, and even in its microscopic structure; and in the centre a large pith, often divided, by the tension caused in the growth of the stem, into a series of horizontal tables or partitions. Such a stem would have been of little use for timber, and of comparatively small strength. Still the central axis of wood gave it rigidity, the surrounding fibres, like cordage, gave the axis support, and the outer shell or hard bark must have materially contributed to the strength of the whole. Growing as those plants did in swampy flats close together, and the bark of which they were chiefly composed being less susceptible of rapid decay than most kinds of wood, and too impervious to fluids to be readily penetrated by mineral matter, they were admirably fitted for the production of the raw material of coal."

We have followed Dr. Dawson in regarding *Sigillaria* as gymnospermous; but there are several eminent investigators of coal-plants, such as Professor Morris and Mr. Carruthers, who maintain it to be cryptogamous.

Our knowledge of the invertebrate fauna of the period is very scanty, still remains have been found which indicate the existence of spiders, insects, and pulmonate gasteropods. No relics have been discovered either of the *Hemiptera* or *Homoptera*, and a few only of *Orthoptera*. One consists of a fragment of a wing from the coal measures of Pictou, which has a very peculiar nervation, and which has been described as *Archimulacris acadicus*. A wing very similar to this in general appearance, and named *Blattina venusta*, has been found in the coal measures of Arkansas in a shale which immediately underlies what is called millstone grit, and is about 15 feet above the highest portion of the carboniferous limestone. A wing, which has never been described, turned up many years ago in the Joggins coal measures. Professor Marsh saw it, and states that, so far as his recollection serves him, it was very similar to *Blattina venusta*. Another species of this genus, or *B. primæva*, has been described from the Saarbrück coal-field. Several specimens of the *Blatta* family, and the wing of a cricket, have been described by Germar from the coal-fields of Westphalia. Grasshoppers are represented by the *Gryllacris lithranthraca* from Saarbrück. The next group of insects belong to the pseudo-neuropterous division of the *Orthoptera*, although they are frequently described as true *Neuroptera*. One of the finest specimens of this kind is the beautiful wing figured in Dawson's 'Acadian Geology,' p. 387. It was found in a bed of shale at Little Glace Bay, Cape Breton. It indicates an insect somewhat similar to the Ephemerids, whose expanse of wing was seven inches, a size surpassing that of any of the living species. It possesses characters which prevent its being placed in any recent family, and which require the establishment of a new family which combines a portion of the characteristics of the *Ephemeridæ* or day-flies, and *Libellulidæ*, or dragon-flies. Mr. Scudder has named it *Haplophlebium Barnesii*. The comprehensive nature of the carboniferous insects is also exemplified in some specimens from shales a few feet above the millstone grit of Illinois. They occurred in ironstone nodules, associated with many other terrestrial organisms. Two of these have been described by Professor Dana as *Miamia Bronsoni* and *Hemeristia occidentalis*. These form the types of distinct families which connect the *Neuroptera* proper with the *Pseudoneuroptera*. The coal measures of the Joggins have afforded a number of crushed fragments which may belong to this order; thus there are some eyes which remind one of those possessed by the *Perlidæ*. The *Phasmidæ* are represented by some specimens from Coalbrook Dale. The *Termitidæ* are represented by four species from the Saarbrück coal-field, named *Termes Heeri*, *T. formosus*, *T. Decheni*, and *T. affinis*.

The *Neuroptera* comprise the *Corydalis*, already mentioned under INSECTA, E. C. vol. iii. col. 265, *Dictyoneura libelluloides*, *D. anthracophila*, and *D. Humboldtiana* from the Saarbrück basin; and the Rev. P. B. Brodie states that he has a large Neuropterous wing in his possession from one of the ironstone bands of the Derbyshire coal measures. No representatives of the *Diptera*, *Hymenoptera*, and *Lepidoptera* have yet been brought to light, for it is not certain that the *Palæocampa anthrax* described by Messrs. Meek and Worthen from the coal measures of Illinois is really a hairy caterpillar. The known Coleopterous fauna of this period consists of two beetles of the family *Curculionidæ* from Coalbrook Dale; a doubtful species from the coal measures near Huddersfield; of *Troxites Germari* from Sulzbach; and possibly some of the specimens which are mentioned as belonging to the next group.

The *Myriapoda* are divisible into the two orders *Chilopoda* and *Chilognatha*. To the latter belong the *Xylobius sigillariæ* found in the inside of a decayed stump in the coal measures at Joggins associated with a reptile and a small land shell; and the *Xylobius* found in the upper coal measures at Kilmaurs, near Glasgow, which is allied to, if not identical with, the Nova Scotian species; and a third specimen found in the Manchester coal-field by Mr. Binney. A specimen named *Anthracerpes typus* found in Illinois is referred to this group, but its myriapodous affinities are very doubtful. A few other species have been obtained from Joggins; some have been assigned to *Xylobius*, and one forms the type of a new genus, *Archiulus*. Nothing is known of the *Chilopoda*. The known *Arachnida* are only four in number, viz., two scorpions from Bohemia, which were described many years ago as *Microlabis Sternbergi*, and *Cyclophthalmus senior*; a spider from Bohemia, *Palaranea borassifolia*, and a second species from Upper Silesia, which so closely resembles the recent genus, *Lycosa*, as to induce Professor Römer to name it *Protolycosa anthracophila*. The last-mentioned species is the oldest spider known, and the details of its external structure have been beautifully preserved.

The oldest known land shells, two in number, belong to this period. One of them is *Pupa vetusta*, of which numerous specimens have been collected in the Joggins coal measures; and the other is *Conulus priscus*, which belongs to the extensive family *Helicidæ*, and was also found in these coal measures.

We have indicated the existence of wide marshy tracts clothed with trees and dense undergrowth, which afforded shade and protection to cockroaches, crickets, may-flies, dragon-flies, white ants, beetles, wood-eating myriapods, scorpions, and spiders. In association with these there have been found the remains of reptiles which are so divergent in their characters as to lead one to conjecture that each known species represents many other contemporary forms which have yet to be discovered. Prior to 1841 nothing was known of carboniferous reptiles; a few bones and teeth were considered to be reptilian, but were subsequently ascertained to belong to fishes. Thirty years ago, then, our knowledge respecting the existence of this class at this period was an entire blank; now we are cognisant of numerous genera and species, and the stimulus which has thus been given to this line of research will probably result in numerous additional discoveries being made in the next thirty years. In 1841 Sir W. E. Logan inaugurated the series of discoveries which we are about to notice by detecting some small well-defined reptilian foot-prints in the lower coal measures of Horton Bluff in Nova Scotia. This is the first fact on record on this subject, and the foot-prints are the oldest traces known of reptilian life. It has been overlooked by most authorities on the subject, owing no doubt to the uncertainty which must attach to the correct interpretation of the affinities of a creature from its foot-marks only. In 1844 Dr. King discovered other reptilian foot-prints in a sandstone at Greensburg, Pennsylvania, situated 100 feet below the well-known Pittsburg seam of coal, figures of which are given in Lyell's 'Elements of Geology.' The tracks are in double rows, and have a broad resemblance to those made by the *Cheirotherium* of the trias. They indicate a quadrupedal animal in which the five-toed hind feet were nearly twice as large as the four-toed fore feet. The external digit on each limb stands out like a thumb. The surface upon which the impressions were made contain the casts of cracks, which indicate its sub-aerial condition, and this circumstance, in conjunction with the decisive character of the ichnolites, permit the assumption that the creature was an air-breather. In the foot-prints discovered by Logan there are to be seen the projecting outer toe, but the impressions are much less distinct than in those found by Dr. King, in consequence, it is imagined, either of the surface having been firmer, or of the animal having been partially buoyed up by water. The fore feet appear to have had four toes, and the hinder three or four. The stride of the Nova Scotian species was about four inches, and that of the Pennsylvanian about ten inches. In the same year Dr. Dawson found some tracks in the upper coal measures near Tatamagouche in Nova Scotia, which are probably reptilian. The year 1844 is, however, especially remarkable as being that in which the first reptilian bones of carboniferous age were discovered. They were exhumed from the coal of Münsterappel in Bavaria, and described as *Apateon pedestris*. In 1847 Von Dechen found in the coal measures of the Saarbrück basin, near Lebach, the skeletons of three species, all of which were assigned to the genus *Archegosaurus*, a type of reptile characteristic of this period. Professor Owen places it in his order *Ganocephala*. In 1849 the red shales near the base of the Pennsylvanian coal formation afforded a series of right and left footed reptilian tracks, which Mr. Lee described as *Sauropus*. These shales are 1700 feet lower than the Greensburg foot-prints. At a level 1500 feet lower still, similar but smaller impressions have been discovered, belonging, as is supposed, to three species. The largest of these made foot-prints two inches in diameter; the feet were four in number, and nearly equal. The stride was about nine inches in extent, and the straddle about four inches. These, and indeed almost all the reptilian ichnolites yet discovered, occur on the surfaces of sandstone beds which are covered with a thin coating of fine clay, on which are preserved the indications of an air-exposed or air-dried shore, such as rain-drop impressions, ripple marks, sun cracks, &c. In 1851 Dr. Dawson whiled away a summer afternoon by turning over a rubbish heap, from the fragments composing which he obtained some cranial bones, which were the first reptilian osseous remains discovered in the American coal measures. In the following year some additional fragments belonging to the same species, *Baphetes planiceps*, were detected by Dr. Dawson and Sir C. Lyell in the interior of an erect Sigillarian trunk. It was from one of these trunks, and in the same year, that were obtained the bones of *Dendrerpeton acadianum*, an animal about two feet in length, with a broad flat head somewhat similar to that of *Baphetes*, short, stout limbs, and an elongated or lacertian form of body. Its teeth were powerful and numerous, and probably adapted for a carnivorous diet. In these trees remains of a second and smaller species, *D. Oweni*, presented themselves, in which the teeth were longer, more arcuate, more plicated, and better fitted for devouring worms, larvæ, and soft-skinned fishes. The same tree which contained the bones of *Dendrerpeton acadianum* also yielded some fragments of a distinct generic type, *Hylonomus Wymanni*. This species is one of the smallest of the carboniferous reptiles, and frequently fell a prey to its larger relatives, as is indicated by the frequent occurrence of its bones in reptilian coprolites. Its length was about five inches. In 1853 Professor Owen described the first British reptile of this period under the name of *Parabatrachus Colei*, a species nearly allied to *Archegosaurus*. In 1857 Wyman established the genus *Raniceps* for a species (*R. Lyelli*), from the cannel coal at Yellow Creek, Ohio, United States. In 1859 Dr. Dawson disentombed from the prolific tree stumps at the Joggins two new species of *Hylonomus* larger than the one already mentioned. One is *H. Lyelli*, a tailed reptile about nine inches long, covered with an armour of scales and spines, and having short, stout limbs fully capable of supporting its trunk on dry land. The second is *H. aciedentatus*, a much larger species than the preceding, and provided with a set of teeth of far greater penetrating and crushing powers. In 1862 Professor Owen instituted the genus *Hylerpeton* for some fragments from the Joggins' tree stumps, which he named *H. Dawsoni*. In this year also some remains discovered at the Joggins in 1855 were made the foundation for a new genus and species, *Eosaurus acadianus*, by Mr. Marsh, who conceived it to be a large air-breathing, cold-blooded, carnivorous creature, foreshadowing the Ichthyosaurians of the lias; but this conclusion is not decisively established. Whatever its true affinities may be, it was certainly the largest of known carboniferous reptiles. Further, the genera *Loxomma* and *Pholidogaster* were established by Professor Huxley on some bones obtained from the Edinburgh coal-field. In the same year also some fragments were brought to light from Mushet's black band ironstone, which is about 666 feet above the Moorstone rock of Lanarkshire, upon which Professor Huxley founded the new genus and species *Anthracosaurus Russelli*. This genus has vertebræ very similar to that of *Eosaurus*, and is noticeable as being the earliest representative of a group of reptiles which flourished in the triassic period. In 1863 Dr. Dawson described a new species of *Dendrerpeton*, or *D. Oweni*, which has been already mentioned. In 1865 the first species from the Welsh coal fields was described by Professor Owen. The specimens came from some beds in the lower half of the coal measures at Llantrissent, Glamorganshire, and are named *Anthrakerpeton crassosteum*. This species was intermediate in size between *Baphetes planiceps* and *Dendrerpeton acadianum*. During the years 1864 and 1865, Mr. Brownrigg accumulated a large suite of specimens from the Jarrow collieries at Kilkenny, which enabled Professor Huxley to establish five new genera. *Urocordylus* has a remarkably long and strong tail, an elongate form of body, a broad short head, and small but well-developed limbs. One species, *U. Wandesfordii*, is described. *Ophiderpeton* is still more lengthy, and almost snakelike in shape. In two specimens no traces of anterior limbs could be detected; but a third, believed to belong to this genus, had minute anterior extremities. One species, *O. Brownriggii*, is described. *Ichthyerpeton Bradleyæ*, is the name for a short-tailed, horny-scaled individual, which had biconcave vertebræ. It was probably about fourteen inches long. *Keraterpeton* is the name proposed for a salamander-like genus, of which the only known species is *K. Galvani*. It was nearly nine inches long, had a well-developed tail, a short broad head, large and forwardly-directed orbits, and a plated dermal armour. The fore limbs were five-toed and somewhat larger than the hind ones, which were four or five-toed. *Lepterpeton* also comprises but one species, *L. Dobbsii*. It has a slender body, an elongated head, and a prolonged snout. Its length was about six inches. Specimens of a species of *Anthracosaurus* were also found. This remarkable find is shortly noticed in the 'Geological Magazine,' vol. iv. p. 170, by Professors Wright and Huxley, and more fully in the 'Transactions of the Royal Irish Academy,' vol. xxiv. In the former work the following remarks are made respecting it. "The importance of the discoveries which have been made in the Kilkenny coal field may be estimated by calling to mind the fact that two months ago the total number of genera of vertebrate animals of higher organisation than fishes, known to exist in the carboniferous rocks of Europe, amounted only to eight, viz., *Archegosaurus*, *Sclerocephalus*, and *Apateon*, in Germany; *Parabatrachus*, *Anthracosaurus*, *Loxomma*, *Pholidogaster* and *Anthrakerpeton* in Great Britain. In addition to these, America had yielded the five genera, *Baphetes*, *Raniceps*, *Dendrerpeton*, *Hylerpeton*, and *Hylonomus*, making a total of thirteen genera for the carboniferous formation in general. One Irish pit has thus yielded, in the course of a few months, more genera than are known from all the American coal fields, and nearly as many as have been obtained from Europe generally. Five-and-twenty years ago only one genus of *Vertebrata* higher than fishes (*Archegosaurus*) was known to occur in the coal; and, curiously enough, this genus, by the imperfect ossification of its vertebral column, and the persistence of its branchiæ, lent strong support to the opinions of those who believed that Palæozoic vertebrates must necessarily be of low organisation. Dr. Dawson's discoveries in the Nova Scotian coal-fields first shook this view, which finally ceased to be tenable when the great *Anthracosaurus* of the Scotch coal-field was found to have well-ossified biconcave vertebræ. The Jarrow discoveries afford a most important aid in the same direction, showing as they do that the Labyrinthodont type was abundantly represented in the carboniferous epoch by animals with well-ossified vertebræ; with no trace of persistent branchiæ; and, to all appearance, just as highly organised as their congeners in the trias. Furthermore, these discoveries have a value of their own in the circumstance that they make us acquainted with forms of Labyrinthodonts of a new character. All previously known Labyrinthodonts have the form of salamanders (the current restorations of the genus *Labyrinthodon*, under the form of a great toad, have no justification, but are contradicted by well-known facts), with long tails and moderate limbs. But *Ophiderpeton*, with its snakelike body, seems to represent, among the Labyrinthodonts, the type of *Amphiuma*, or perhaps of *Cæcilia*, among existing *Batrachia*. Should further investigations bear out this view, three groups will be recognisable among the Labyrinthodonts: a perennibranchiate division, represented by *Archegosaurus;* a salamandroid group, comprising most of the Labyrinthodonts at present known; and an ophiomorphous division, typified by *Ophiderpeton*. The anurous frog-like form will be alone wanting to complete the representation of the existing *Amphibia* in ancient times." In 1866 a reptilian skull was found in the upper part of the carboniferous series near Autun. Some of the strata on the same horizon bore impressions of feet which are conjectured to belong to the same species. The reptile is nearly allied to *Archegosaurus*, and is the type of a new genus, *Actinadon*. In 1867, Professor Owen gave the name of *Gastrodus præpositus*, to what he considers was an air-breathing Batrachian from the lower coal measures of Northumberland. In 1868 Professor Newberry noticed some reptilian remains from a stratum a few feet beneath the principal coal-bed at Linton, Ohio, which are partly related to the genera *Ophiderpeton* and *Urocordylus*.

Such are the principal items in the chronology of reptilian discoveries in the carboniferous formation; but before we bring this article to a close we would quote Professor Huxley's remarks (Quarterly Journal Geol. Soc., xix. p. 67), bearing upon the general affinities of the carboniferous reptiles. "At present we are acquainted with two apparently very distinct types among the Labyrinthodonts—that of the *Archegosauria* (*Archegosaurus*), at present known to occur only in the carboniferous rocks, and that of the *Mastodonsauria* (*Mastodonsaurus, Labyrinthodon, Capitosaurus, Trematosaurus*), which seem to have flourished in remarkable abundance during the triassic epoch. Both groups exhibit the sculptured and polished surface of the crania, the vomerine and palatine teeth, the forwardly situated posterior nares, the permanently distinct epiotic bones, the divided supra-occipital, the three sculptured pectoral plates, the elongated caudate, salamandroid body, and the comparatively short limbs and weak feet, which are distinctive features of the Labyrinthodont *Amphibia*, as well as the more or less complex ramifications of the pulp cavities of the teeth, which they share with fishes and *Ichthyosauria*. But the *Archegosauria* have imperfectly ossified vertebral bodies, while the *Mastodonsauria* have them thoroughly well ossified, though still biconcave; and the *Mastodonsauria* have double ossified occipital condyles, which have not been found in *Archegosauria*. Of the other distinctions, if such there were, of the two groups we know very little. It is true that the *Archegosauria* had, as Von Meyer has proved, in his splendid monograph, 'Die Reptilien des Steinkohls,' a persistent branchial apparatus, and a very remarkable scaly ventral armature. But what do we know with certainty about the presence or absence of corresponding structures in the triassic *Mastodonsauria?* Whatever may be the nature of the doubtful *Anisopus* or *Rhompholis*, it is certain that the African, probably triassic, *Micropholis* was protected by ventral scutes; and until Mastodonsaurian Labyrinthodonts are found preserved as favourably as the *Archegosauria* have been, I think it will be hazardous to take it for granted that they had neither ventral scutes nor even persistent branchial arches.

"If we adopt these two divisions, and endeavour to range the known carboniferous Labyrinthodonts under one or the other, *Archegosaurus*, of course, takes its place among the *Archegosauria*, and *Pholidogaster*, I suspect, must go along with it, though the vertebræ are far better ossified, and the condition of the cranial condyles is not known. *Baphetes* and *Parabatrachus* are too little known to justify us in arriving at any conclusion respecting them; and the like is true of *Loxomma*. As regards the *Raniceps* of Wyman ('American Journal of Science and Arts,' 1858), the *Dendrerpeton* and *Hylonomus* recently discovered by Dr. Dawson in the Nova Scotian coal-field, and the new genus instituted by Professor Owen, from the same locality, I do not think we are in a position to say that they are Labyrinthodont, much less whether they have Archegosaurian or Mastodonsaurian affinities. Among the many remains discovered by the zealous researches of Dr. Dawson, I do not know that a single specimen of one of the pectoral plates, so characteristic of all Labyrinthodonts, has made its appearance. They may possibly have been *Amphibia*; but their skulls, their cycloid scales, and their deeply biconcave, fish-like, vertebral centra, appear to me to indicate a closer affinity with the *Ophiomorpha* (*Cæcilia, Ichthyophis*, &c.), than with the *Labyrinthodontia*. Of the unquestionable Labyrinthodonts which occur in the carboniferous rocks, then, *Anthracosaurus* is the only genus regarding the vertebral column and ribs of which there is any information; and the descriptions and comparisons which I have given seem to me to necessitate the conclusion that, side by side with the Archegosaurian type, the Mastodonsaurian type of vertebrate organisation, hitherto known to occur only in the trias, was well developed in the *Anthracosaurus* of the Scotch coal-field. At the same time, the anchylosed condition of the neural arches, the supra-temporal foramina (which may, however, be parts of the 'mucous grooves' common upon Labyrinthodont skulls, the floor of which was very thin, or merely membranous in the temporal region of *Anthracosaurus*), and the strong median convexity of the snout, separate *Anthracosaurus* from any known triassic Labyrinthodont. And though, in the general form of the cranium, and in some other respects, *Anthracosaurus* has a certain resemblance to the Permian *Dasyceps*, it differs as widely as possible from it in its dentition."

CASSITERITE [Gold, E. C. S.]

CAUDISONA [Viperidæ, E. C. S.]

CAVES. A cave, or cavern, is a large hollow in the ground formed artificially, as by man, or by natural agents, such as running water. Old English writers usually applied the term to those hollows which were inhabited either by man or beast. Some of these caverns are now the receptacles for the waifs and strays of beings which have ceased to exist, and it is the main purpose of this article to offer some remarks upon such of them as are more especially interesting in connection with the period of intense cold during the post pliocene epoch, and the past history of man's association with large extinct mammalia. These hollows have doubtless been in process of formation from the earliest to the latest geological times, but those which we are about to mention have been filled and perhaps formed during a short period in geological history; and it must not be inferred that because we dwell upon these that caverns have not been equally plentiful in older epochs. It is true caverns of earlier date than the late tertiary and post-pliocene periods are exceedingly rare, but this seems due partly to their having been filled up and covered, and partly to the rock masses in which they were, having been denuded away. The natural caverns may be conveniently distinguished as belonging to two great groups, the one including such as have horizontal entrances only, and the other those which communicate, or have formerly communicated, with the surface by more or less vertical fissures. The breccia-filled fissures will be described along with the latter, although there may be no indications that they lead into caverns. Fissures are produced in various ways; thus many have been known to open during earthquakes, swallow up human beings, animals, and even towns, and again to close; others appear to arise from the unequal upheaval and depression of limited areas, and to serve as traps for unwary animals; and others are clearly the channels for subterranean springs and rivulets. Fissures are comparatively numerous in rocks of all ages and of all compositions; appearing now as veins or as ossiferous breccia, such as the fissures in the carboniferous limestone of Holwell, in which have been found the remains of Rhætic mammals. Fully admitting the multitude of ways in which these hollows in the ground have been formed, we have now to consider a special class of caverns and fissures.

These caverns are for the most part the result of underground denudation and are especially abundant in those rocks which are most soluble in water, such as limestone. From the nature of their contents it would seem that they were produced in unusual abundance during certain parts of the post-pliocene period. Why the solvent and hollowing out powers of the waters should have been exceptionally active at these periods it is difficult to say; and it is equally difficult to pronounce why so many of the organic remains found in these caves should belong to one geological epoch.

In order to illustrate the past by what is going on at the present time, a reference to some recent caverns is required. In many limestone districts, as in the Derbyshire hills and the chalk near London, the surface of the ground is riddled with funnel-mouthed chimney-like passages, which are known in many cases to be the channels down which the rain floods pour, and hence they are termed swallow holes. The Silurian limestones of Pennsylvania are also riddled with similar holes, through which rivers are discharged into underground caverns, which underlie the surface along a line many miles in extent; but perhaps there is scarcely any country in which the limestone is more riddled with swallow holes, or *Katavothra*, engulfed rivers so abundant, and underground caverns so extensive, as in the Morea. These were fully described upwards of thirty years ago by M. Boblaye and other members of a French expedition to Greece. The caverns of Morea are in a hard limestone of the age of the chalk of England, which is underlain by arenaceous strata equivalent to the upper greensand of England. The year is divided into a dry season of about eight months' duration, and a wet period of about four months. During the continuance of rain the waters pour into deep hollows in the highlands, some of which are miles in diameter. The torrents are charged with pebbles and a red ochreous earth, such as abounds everywhere on the surface of the decomposing limestone of the surrounding country, and in many cases disappear through the fissured and cavernous limestone which bounds the hollow. Sometimes the swallow holes are partially or wholly blocked up with débris, and then a temporary lake arises which pours its surplus waters through other openings situated at higher levels. The waters are turbid on entering, but on reappearing again in springs miles away they are clear and limpid. The springs are surprisingly uniform in their yield, a circumstance which indicates that the caverns are sufficiently large to serve as reservoirs. The principal swallow hole, or *Katavothron*, is frequently at the foot of the surrounding limestone escarpment, and large enough for persons to enter during the dry season. The bottom of the lake then appears as a level plain formed of a red mud, cracked in all directions. On entering the swallow hole we pass into a series of lofty arched chambers connected by narrow passages; the floor is frequently covered with the same red earth as forms the outside plain, and it has been found to contain the remains of plants and animals now living in the Morea, and occasionally human bones. It is not uncommon for the outer mouth to be half closed with red mud and hidden by luxuriant vegetation. Under such circumstances the caverns are the favourite haunts of jackals and foxes, who drag their prey into them in order to devour it at their leisure. The Morea is not, however, by any means singular in possessing these phenomena, for they are to be seen in Italy, Spain, Asia Minor, Syria, and elsewhere. They are also very abundant in many limestones which are covered at times with snow and ice, as on the elevated plains of the Teutoburger Wald, on the Gemmi in Switzerland, and on the northern part of the chalk in Denmark. The springs of these districts and the frequent caving in of the ground testify to the magnitude of the scale upon which these operations are silently being effected. In many cases the caves are filled temporarily or permanently with water; thus the ground forming the Teutoburger Wald is estimated by Bischof to have as much water hidden within its recesses as would form a large lake 120 feet in depth.

Let us, then, compare this with some of the old caves, of which that of Wookey Hole, described by Dawkins, will be a good illustration. Wookey Hole is a small village at the base of the sloping flanks of the Mendips, which at this part face the south-west. The lower part of this slope is a dolomitic conglomerate, which lies underneath what was formerly a cliff of carboniferous limestone. A ravine cuts through the slope, and at its upper end terminates against the limestone cliff, at the base of which is a cave from which the river Axe makes its exit continuing its course down the ravine. This cave is the one which Dr. Buckland explored many years ago. That which is now under notice was discovered in cutting a passage or canal for the more convenient conveyance of the water of the Axe to the village of Wookey Hole, and is designated as the hyæna den of that locality. The den is a sinuous cavity about 70 feet in depth, and filled to the roof in most places with transported materials. It consists of a large entrance hall, or antrum, which narrows from an aperture forty feet wide and nine feet high, to six feet by four feet; this leads into a long passage which almost disappears in a forward direction, but gives off on its right hand side a branch as large as itself, which terminates in an upward tending passage. In the antrum there is also a lateral passage to the left. A section in the antrum showed that its materials were arranged as below:—

a. Roof.
b. Red earth, containing a large quantity of stones and but few organic remains, two feet in thickness, and reaching to within one or two inches of the roof.
c. Red earth with irregular layers of album græcum and peroxide of manganese, and containing an elephant's tusk, together with teeth, and numerous splinters of bone; seven to eight inches.
d. Red earth containing stones and a few organic remains; four feet.
e. Floor, worn by water, and corroded by carbonic acid.

In the main passage and the branch diverging from it, the arrangement is almost identical with that in the antrum, the chief difference being that the upper surface of the red sand is about five inches from the roof, and is covered by a thin layer of stalagmite; that a mass of conglomerate which had fallen from the roof is imbedded nearly two feet in the clay just above where the layers of album græcum occur; and that in one or two places a bone bed and an overlying layer of red earth occur above the red earth, indicated by *b* in the preceding section. The bone bed and red clay abut against a layer of sand and a mass of grey clay which occupies each of the ascending terminal portions of the cave. The layers of peroxide of manganese did not continue into the passages.

The organic remains were generally distributed through the red earth, but were most concentrated in the bone bed, and were more numerous in the antrum than anywhere else. Upwards of 1500 osseous fragments were collected belonging to the following species:—

Hyæna spelæa. More abundant than any other.
Felis spelæa. Not common.
Felis (species). Not common.
Ursus spelæus. Not common.
U. arctos. Very rare.
U. (species). Rare.
Meles taxus. One fragment only.
Canis lupus. Thirteen fragments.
C. vulpes. Eight fragments.
Elephas primigenius. Frequent.
Rhinoceros tichorhinus. Plentiful.
R. Merckii. One fragment.
Equus fossilis. Plentiful.
Bos primigenius. Sixteen teeth.
Bos (species). Frequent.
Megaceros hibernicus. Frequent.
Cervus tarandus. Two fragments.
C. elaphus. Rare.
C. (species). Frequent.

In addition to these were several implements made by man, all of which were found in the antrum. They consist of an oval shaped spear-head formed out of flint, a chert arrow-head, some roughly shaped pieces of chert, and numerous splinters of flint. They were all found together in the red earth, and between the layers of peroxide of manganese.

The general conclusions which Dawkins draws from his researches are so important, if they stand the test of future investigation, that we prefer giving them nearly in his own words. We are, however, inclined to suspect that the evidence does not warrant the inference that man and the fauna of this cave date back so far as he supposes. He remarks ('Quarterly Journal of the Geological Society,' xix. p. 272, *et seq.*) that the group of animals just noticed throw great light upon the physical geography of the district in the days of the hyæna. In the absence of the beaver and the otter, of the water-rat and the hippopotamus, we may see that then, as now, there was no large river in the immediate vicinity. The great preponderance of the horse and rhinoceros is very remarkable. The great number of the former compared with the few in the Kirkdale hyæna den may, perhaps, show that they were more plentiful in the west than in the north of England. Both indicate the existence of an extensive plain in the neighbourhood; while the various species of *Cervidæ* point to woodland on the flanks of the Mendips, and encroaching on the plain at their base. But this evidence does not stand alone. The physical configuration of the west coast of Somerset, the jaws of *Rhinoceros tichorhinus* at Taunton associated with oak, ash, and elder, prove that a level district extended in those days, with but little interruption, from the Mendips to the Devonian range of the Quantock, and advanced westwards into the Bristol Channel, and possibly into the Atlantic. The higher ground of South Wales, in the mountain limestone of which bone caves are so numerous, probably formed its northern boundary. The mountain limestone border of this great plain would obviously be most favourable for the habitation of the large number of carnivores—the hyænas, the three, if not four, species of bear, the two species of *Felis*, the foxes and the wolves. We should naturally expect to find them here in greater variety and numbers than in any less favourable place. Subsequently to this came a great depression of the district, followed by a great upheaval. In none of the deposits formed while the movements were going on, have any relics of the cave fauna, except the fox, Irish elk, and red deer, been found. Hence the cave was inhabited and filled prior to the period of submergence, while the presence of *Rhinoceros Merckii* may indicate that the cave fauna belongs to the late part of the pliocene epoch, or as old as the Bridlington crag. After alluding to the peculiarities of the worked fragments of stone, and the places where they were found, the author thus concludes his paper:—"The whole body of evidence tends to prove that man, in one of the earlier stages of his being, dwelt in this cave; that in it he manufactured his implements out of flint from the chalk-downs of Wilts, and from the less fragile chert from the greensand of the Blackdown hills, and arrow-heads out of the chert and the more easily fashioned bone; and that beyond all doubt he was a contemporary with the extinct fauna found, with the traces of his existence, in the cave. Then, after an interval, in which much of the fauna became extinct, and in which the whole of the district was considerably depressed, we again meet with traces of man in the coarse pottery and the human teeth found by Dr. Buckland in the great Wookey Hole cavern. And, lastly, the discovery of coins of Allectus, Comes littoris Saxonici, together with skeletons near the hyæna den, brings us down to the fourth or fifth century after Christ. Thus palæontology shades off into archæology, and that into history, and each, taking up the thread where the other dropped it, shows the intimate relation between sciences formerly considered to have little or no bearing upon each other. Until, however, there are data for estimating the magnitude of the breaks in the succession, it is impossible to reduce the interval between ourselves and the flint-folk to the scale of time used in history. The supplanting of one species by another, and the oscillations in the level of the surface prove that the lapse of time was enormous; but they do not warrant us in reducing it to any definite number of years."

It appears, then, that this cave is supposed to have been inhabited both by man and beast before the glacial period of the post-pliocene epoch, and to have an antiquity greater than has been claimed for any other ossiferous cavern that has yet been discovered. However probable the conclusion may be, we confess it does not appear to us to be established beyond all doubt. The corroded floor of the cavern, the accumulation of red earth, the scattered arrangement of the organic remains in it, the position of the bone bed within three or four inches of the roof, the presence of vertical and lateral passages, the layers of album græcum at a particular horizon far below where the great bulk of the bones were collected, are all phenomena which would be the result of a condition of things similar to that described in the Morea. The red earth and most of the bones would be introduced during the periods of floods when the cave would be filled with water, and remain filled until the floods had sunk below the level of the roof of the cave. The subsidence would be slow, and unaccompanied by any violent water action, and the cave would return to a condition fitting it to become the habitation at one time of man and at another of various species of wild beasts. Mr. Dawkins admits the possibility of floods having raised the bone bed nearer to the roof, but contends that the hyænas were the only agents by which the bones were introduced. This, he remarks, is shown by the circumstance that every bone has been gnawed by hyænas, by the presence of the layers of album græcum in the red earth, and by the absence of watery action on the organic remains. Admitting these facts, we still believe it to be possible, although we will not say anything as to the probability of the case, that the gnawed bones and the hyæna's coprolites may have been introduced by water from without the cave, and yet not exhibit any marked traces of erosion. Further remarks will be made as to the bearing of the fauna and the red earth upon the probability of the cave not having been filled in the pliocene period in describing other caverns.

The hyæna den has some features which are common to it and the majority of ossiferous caverns. First, it is clear the cavern was formed before, and it may be long before, the introduction of the materials. There would seem to have been two successive periods: in the first, the condition of things favoured the excavation of the hollow, while in the second, the excavation wholly or almost entirely ceased, and accumulation was in the ascendant. During this second period, also, conditions prevailed from time to time whereby the carbonated waters were compelled to give up their carbonate of lime, which generally forms either alone or with oxide of iron the cementing material of the earth, or bones. The way in which the hyæna den is associated with other caverns, and the frequency with which suites of caverns are connected with the present or former drainage system, indicate that the hyæna den was formerly a passage for water. The caves or passages are frequently arranged in lateral branches debouching upon a main ravine or passage, reminding one of the dendritic arrangement of water-courses. The hyæna den forms one of such a system, and the lateral branches in it are a frequent feature of caves. In the Mendips there are several examples of a system of caverns, some of which still afford passage for waters, while others are dry; and Barrington Court, Cheddar Run, and Wookey Hole are cited by Mr. Dawkins as eminently typical. In course of time the caves are unroofed and converted into ravines. Indeed, many of the limestone ravines have originated in this way. The corroded floor of the cavern points to waters with a large proportion of carbonic acid in solution as the active excavating agent. At ordinary temperatures water will absorb its own volume of carbonic acid, but at 32° F. it will absorb nearly twice its own volume of that gas. This relationship between the absorptive power of the water and its temperature, the increased solvent power of the most highly carbonated water and the apparently unusual solvent powers of the surface waters of a particular period, suggest the idea that the caves may have in many, perhaps in most, instances been dissolved out by ice-cold waters. Moreover, it seems highly probable, as will be pointed out in a later part of this article, that this unusual activity of excavation took place just about the time when the glaciers were dissolving away a few degrees to the north of where the caves are found, and when we would expect the heavy snows of the ossiferous cave district, would give rise to floods of ice-cold water. If, then, we can associate these caverns with a time when floods of cold water were prevalent, some explanation seems to be afforded why the fauna in the caves should belong to a particular geological period. The red earth, which is so general a feature in these caverns, also favours the views above suggested. The Wookey Hole hyæna den is almost entirely filled with it; but as it is formed entirely from the insoluble portion of the limestone, it is at once evident that this accumulation of red earth represents a mass of limestone many times more bulky than the cubic capacity of the cave itself. It either represents many other caves, or, what is more likely, it represents so much limestone which has been dissolved away by the snows and rains which have fallen upon the general surface of the country. On the melting of the snow the insoluble red earth would be washed into the caverns. The period during which such operations went on was probably of considerable duration, and, indeed, sufficiently long to permit of considerable changes in the fauna. M. Lartêt, recognising this lapse of time between the earliest and latest cavern deposits, has attempted to construct a kind of chronological table, based upon the extinction or disappearance of certain species from France. This table is given under POST-PLIOCENE, E. C. S., but may be conveniently repeated here. He believes the species disappeared nearly in the order indicated, and recognises four distinct periods characterised by the existence of the cave bear, tichorhine rhinoceros, reindeer, and aurochs, in accordance with which we have divided the list into four groups.

1	Ursus spelæus. Hyæna spelæa. Felis spelæus.
2	Elephas primigenius. Rhinoceros tichorhinus.
3	Megaceros hibernicus. Cervus tarandus.
4	Bison priscus. Bos primigenius.

Garrigou has proposed a modification of this list, based upon a larger number of observations. He believes the order was as follows:—*Ursus spelæus*, *Elephas primigenius*, *Rhinoceros tichorhinus*, *Felis spelæus*, *Hyæna spelæa*, *Megaceros hibernicus*, *Cervus tarandus*, *Bos primigenius*, *Equus adamiticus*, and *Bison europæus*. And if we arrange them in the order of their first appearance in France the order will be thus:—*Ursus spelæus*, *Megaceros hibernicus*, *Bison europæus*, *Felis spelæus*, *Hyæna spelæa*, *Elephas primigenius*, *Rhinoceros tichorhinus*, *Cervus tarandus*, *Bos primigenius*, and *Equus adamiticus*.

Although Lartêt's list is intended to apply to France only, we shall adopt it as a convenient means of arranging the caverns of western Europe to which we may have occasion to refer. As *Ursus spelæus* is one of the species found in the hyæna den at Wookey Hole; and as *Hyæna spelæa* is the characteristic species of that cavern, it may conveniently be regarded as of the same age as other caverns which contain one or other of the first three species on the list. In the hyæna den the cave-bear is not common, while after the hyæna the remains of the tichorhine rhinoceros and fossil horse are most abundant. Near the shores of the Gulf of Lyons in the south of France, and between the 43rd and 44th degrees of latitude is a cave at Lunel Viel, the fauna of which has considerable resemblance to that of the hyæna den at Wookey Hole. It has been described by Serres in a bulky volume illustrated with numerous plates. The remains of what were considered to be 36 species were described, of which 17 were carnivores, 5 rodents, 6 pachyderms, and 8 ruminants, but it is probable that several of the species are simply varieties. They include *Ursus spelæus*, *U. arctoideus*, which is now regarded as a variety of the cave-bear; *Meles taxus*, *Hyæna spelæa; H. prisca*, and *H. intermedia*, both of which are doubtful species; *Felis spelæus*, *F. ferus*, and other species of *Felis* nearly allied to the African lion, the leopard, and serval; *Canis lupus*, *C. vulpes*, and an undetermined third species; *Elephas primigenius*, *Rhinoceros megarhinus*, and *R. Merckii;* two races of *Equus*, whose remains are plentiful; *Bos intermedius*, and *Bos sp.*, both of which are not unlikely the same as *Bos taurus;* four species of *Cervus*, respectively named *intermedius*, *coronatus*, *antiquus*, and *pseudo-virgineus; Sus priscus* and *scrofa;* and also species of beaver, *Mus*, and *Lepus*. Allowing for difference of latitude, and the difficulties of settling synonyms, there is considerable resemblance between the fauna of the hyæna den in England and this cave in the south of France. The most noticeable points of difference appear to be the presence of several large felines, which are wanting in England, and the absence of the tichorhine rhinoceros, Irish elk, reindeer, and *Bos primigenius*, in the French cave. The stags, horses, and oxen were the most prevalent herbivores, and the cave-hyæna the most abundant carnivore. Associated with these remains are specimens of human handiwork, and the coprolites of hyænas; but Serres, after remarking that the bones were introduced as bare bones, and even gnawed before their introduction into the cave, denies that the presence of coprolites is any proof that these hyænas ever dwelt in this cave. He believes the materials were introduced by violent inundations. Originally Serres regarded the evidence afforded by this and other caves as indicating that man was the contemporary of the animals with whose remains his workmanship is found; and Desnoyers opposed the conclusion, on the ground that the materials had been re-arranged. Of late years, Serres has expressed his conviction that no human remains, not even the oldest, were the contemporaries of the elephants, rhinoceros, hippopotamus, and great lions, which once ranged through western Europe; while on the other hand Desnoyers has been an ardent advocate of the extreme antiquity of man. Another, and one of the most famous and most carefully explored caverns of the *Ursus spelæus* group is that known as Kent's Cavern, or Kent's Hole, situated one mile to the east of Torquay Harbour. It has been the subject of scientific investigation from as far back as 1824, when it was visited by Mr. Northmore, who asserts that he discovered a temple in it dedicated to Mithras. He was followed by Mr. Trevilyan, by Mr. M'Enery in 1825, and subsequent years; by Godwin-Austen in 1840; by a committee of the Torquay Natural History Society in 1846; and finally, by a committee of the British Association, which commenced its labours in 1864, and read its third report at the meeting of the above-mentioned Association at Dundee in 1867, and its fourth report at the meeting at Norwich in 1868. This cavern is situated in a limestone hill on the western side of a small valley which, running north and south, terminates on the shore near Torquay. On the eastern slope of the hill, or that which faces the valley, and at an elevation of from 180 to 190 feet above the mean level of the sea, is a low natural cliff, in which are the two principal entrances to the cave. They are nearly on the same level, 50 feet apart, and about 70 feet above the bottom of the valley. The northern entrance leads by a short narrow passage into a large spacious hall, termed the Vestibule, or Sloping Chamber, and this communicates with other chambers and passages, to each of which a name has been given; the length of the whole series, from north to south, or parallel to the main axis of the valley, being upwards of 200 feet. The floor of the cavern is covered with deposits, which almost uniformly have the same succession so far as examined. On the limestone floor itself, which has been reached in a few places, is a red cave earth, with angular pieces of limestone, a few rounded stones of foreign origin, numerous bones, and articles worked by man. Above this is a stalagmitic floor, with an average thickness of from 12 to 18 inches, the extremes being 3 inches and 3 feet. A layer of black mould, varying from 3 to upwards of 12 inches in depth, rests on the stalagmite; and upon this are some large angular blocks of limestone. The red cave earth is a mixture of loam and stony fragments, in which sometimes the loam and sometimes the stones predominate. The stones are placed at all angles, and show no signs of stratification. In places there is evidence of a considerable drip having formerly existed in the cavern, since the red earth is frequently cemented together by carbonate of lime. At the present time the cave is remarkably dry. A large number of broken bones and splinters are distributed throughout the red earth, although they are somewhat rare in the upper portions of it. Many of the bones appear to have been gnawed and afterwards rolled; while a small proportion have been split longitudinally, which also bear the marks of teeth, supposed to be those of hyænas. The bones also have white stains, such as are left after the removal of lichens and mosses. They are heavier than the bones found at higher levels, and are frequently of a chalky whiteness. They belong to the cave-bear, cave-lion, cave-hyæna, fox, horses, ox, several species of deer, tichorhine rhinoceros, mammoth and badger; an assemblage which reminds one of the contents of Wookey Hole, but the resemblance is more marked when we find that the hyæna was perhaps the most abundant species, and next to it the rhinoceros and the horse, while the mammoth is comparatively rare. Numerous implements of bone and stone have also been found in the red earth. Flint and chert are the principal materials, and the prevailing form is a flake flat on one side, with a slight ridge on the opposite, although specimens of the lanceolate and oval types were met with. In noticing the deposits we stated that a certain order generally prevailed; and that the stalagmite succeeded to the cave earth. In the Vestibule, however, the cave earth is separated from the stalagmite flooring above by what has been termed a *black band*, which covers an area of 100 square feet, and in one spot is itself separated from the stalagmite floor by a thin layer of cave earth. This black band contained numerous bits of charcoal, and yielded many interesting objects. There were bones and teeth of the ox, two or three species of deer, horse, badger, cave-bear, cave-hyæna, fox, and tichorhine rhinoceros. Associated with these were hundreds of implements, most of them were flakes of flint, but still there were numerous perfect lanceolate tools. Of the bone tools one was a fine-pointed awl, 3½ inches long, and another a harpoon, barbed on one side only. The flooring of stalagmite stretched in most places from one side of the cave to the other; but there were holes, or gaps, in it in certain places where the drip from the roof was slight, or where some of the large blocks from the roof had fallen on to the upper surface of the red earth, and interrupted the continuity of the flooring. In one chamber its surface was uneven, being higher at one side than the other; but the level was in part restored by a second sheet of stalagmite, which extended from the highest sides of the floor in one direction to the wall of the chamber in the other, while a hollow space representing the difference in the level of the floor intervened between the lower and upper sheets of stalagmite. The higher sheet is described as the ceiling. Respecting this ceiling, the Committee make the following remarks in their report for 1866:—"The nether surface of the ceiling is of a beautifully stainless cream colour, and sends down a profusion of small stalactites. When first discovered, the ceiling was supposed to be a stratum of limestone *in situ*, completely invested with a mere film of stalagmite. In order to determine its true character several holes were bored through it, when it was found to be exclusively stalagmite throughout—granular, and comparatively soft in the upper part, but highly crystalline towards its base. The origin of the mass is not a little puzzling, for whilst on the one hand it seems necessary to suppose that it was formed on a basis either of limestone *in situ*, or of detrital matter mechanically accumulated; on the other, it is difficult to understand how this basis could have been removed so completely as to leave behind no trace of stone or bone. Such ceilings occur in the famous Brixham cavern on the opposite shore of Torbay, but to their lower surfaces there cling numerous stony and other relics of the deposits on which they were moulded. After a careful study of the case, the Superintendents of the exploration incline to the opinion that the ceiling was formed as a floor on a deposit of fine earth, which once filled the gallery to the necessary height, or in other words, to the prevalent level of the deposit in the adjacent chamber; that this deposit, either by a considerable subsidence or by being washed out, was completely detached from the floor which overlay it; and that subsequently a second and lower floor was formed in the gallery, and additions were made to both the upper and the lower surfaces of the ceiling or first floor. In support of this opinion it may be stated that the cream-coloured stalagmite forming the lower surface of the ceiling, instead of being characteristic of the entire mass, is but a sort of veneer, nowhere more than an inch thick. On being stripped off, it is found that both in texture and in colour it is strongly contrasted with the material to which it was attached. The newly-exposed surface, and the surface only, has the exact colour of the cave earth; in fact, it is soil-stained, and thus harmonises well with the hypothesis. Again, the abruptly-truncated character of its eastern end, or commencement, renders it not improbable that the ceiling is the remnant of a floor which formerly extended eastward into the chamber, but which has there partially perished. Further, that a floor has been destroyed, either wholly or partially, is conclusively proved by the fact that a large number of fragments of stalagmite were met with incorporated in the existing floor, and also in the cave earth below, both in the chamber and in the gallery." In places this stalagmitic flooring is brecciated, as though it were composed of broken pieces of stalagmite re-cemented together. The stalagmite has yielded, more especially in the lower and more brecciated portions, fragments of charred wood; various land and fresh water shells; bones of recent species, such as fox, horse, and man, as also others belonging to extinct species, such as the cave bear; and flint flakes and implements, together with the only fragmentary specimen of polished celt yet found in the cave. The human remains consisted of a tooth and portion of an upper jaw with four teeth in it. The black mould above the stalagmite has yielded numerous objects, but as yet they have appertained either to man or to recent species. Amongst the bones the most interesting were several fragments of a human skeleton, including vertebræ, lower jaw with teeth, and a skull. The other objects are of a very miscellaneous character. They comprise numerous well-rounded pebbles, perforated by lithodomous molluscs; whetstones; pieces of slate; hundreds of flint flakes; a spoon, a fibula, and a socketed celt, made of bronze; a fragment of smelted copper; large quantities of broken pottery; a comb, spoon, and chisel, formed of bone; spindle whorls, hazel-nuts, and charred wood; glass wine and porter bottles; and two or three coins issued in the present century. This is not a complete list of the objects discovered, but it shows their general character. The stones appear to have been introduced from the neighbouring beach. The pieces of slate are supposed to have been used as covers for earthenware vessels. The pottery is chiefly coarse, unglazed, and marked with patterns similar to those known to have been adopted by the ancient Britons; but one small piece was of a superior character, and is said to be undoubtedly Samian. Among the bone tools are several combs of a form common amongst the British, or that of a shoe-horn, with the teeth at the broad end, and lines of ornamentation on the handle. The spindle whorls also are numerous, and are formed in several varieties of hard rocks, such as grit, schist, and Kimmeridge coal. The flint flakes were most abundant in the Vestibule, and the bones were far lighter than those found in the cave earth. The state of the black mould in the Vestibule shows that this was the principal place of abode for man. The floor is strewed with marine shells, more especially such as belong to the edible kinds. The refuse oyster-shells form considerable heaps, and the limpet, whelk, cockle, mussel, pecten, razor-shell, and cuttle-fish, also appear to have been favourite articles of food; while the marks of fire on many of the bones which belonged to the pig, deer, sheep, fox, hare, rabbit, birds, and numerous varieties of fish, indicate that these also may have entered into the bill of fare. The black mould extends into another chamber called the 'lecture hall,' and has yielded similar articles as that in the Vestibule. Most of the authorities which we have consulted regard the evidence afforded by this cave as proving decidedly that man was the contemporary of the cave bear, cave lion, cave hyæna, and tichorhine rhinoceros, and consequently carry back the age of man to the time when they lived. They rely upon the general body of the evidence rather than upon a few facts; but the principal data upon which their belief is formed are the association of implements of various kinds made by man, as also his bones, with the bones of those extinct animals; the peculiar way in which the bones (of what species the reports do not inform us) are split longitudinally for the purpose of extracting the marrow, and their subsequent gnawing by hyænas; and others which need not be mentioned. After referring to the labours of their predecessors, the Committee of the British Association intimate that their chief results have been to confirm and establish on a firmer basis the discoveries already made, and that they themselves have advanced the inquiry by a few steps only. In their first report, in 1865, they were enabled, they say, to add "the new fact that several pieces of burnt bone, as well as a stone having the appearance of a whetstone, and undoubtedly of distant derivation, had been met with in the cave earth. Before the end of another twelvemonth their attention had been arrested by a further phenomenon, and in the second report they remarked that many of the long bones had been split longitudinally, and that it was difficult to suppose that less than human agency could have so divided them. In their third report they are able to advance another step, and to record the discovery of bone tools, about the character of which there can be no difference of opinion, which have the mineral conditions characteristic of bones found in the deposit they occupied, which occurred with the remains of extinct mammals in soil indubitably intact, one of them at the greatest depth to which the excavation has been carried, and all of them beneath a thick unbroken floor of stalagmite, which has itself yielded remains of at least three of the extinct cave mammals. These successive discoveries, after labours so protracted, are calculated to warn us not to place implicit confidence in merely negative evidence; to encourage the hope that the bones of man may yet be exhumed, though probably in sparing numbers only; and should this hope be never realized, to justify even the most cautious in holding and avowing the belief that man was, in Devonshire, the contemporary of animals that had become extinct before the times of history or of tradition." Such has been the care bestowed upon these researches, that one willingly admits that most of the statements made by the committee cannot be gainsaid, but even if the consummation of all their hopes, the finding of the fragments of a human skeleton in the cave earth, be realised, there seems to us something yet to be done before the most cautious will avow that man lived at the same time as the cave bear. We question none of their facts, nor do we feel inclined to assert positively that their conclusions are wrong. Nevertheless, we think there is reason yet for holding that the case is not proven. The general character of the faunas of the red earths of the hyæna den at Wookey Hole and Kent's Cavern is so similar that both appear to belong to the same age. If the men who made the implements in the red earth of the one cave existed in the latest part of the pliocene period, then we should be strongly disposed to think those who made the flints in the cave earth of the latter did so also. But, as appears to us, the great point that wants deciding now is, whether the cave bear, the cave hyæna, and their contemporary associates were living with man at the time when the last arrangement of the red cave earth took place. In the case of the hyæna den, Mr. Dawkins assures us the red earth has never been disturbed since it was first deposited; but in the case of Kent's Hole there seems to be clear evidence of such a disturbance. If we mistake not, the red earth has been deposited in the cave, then covered by a thick layer of stalagmite, the covering broken up and mingled pell-mell with the red earth, the whole again covered with a stalagmite layer, a portion of the earth removed from under this, followed by yet another layer of stalagmite over a portion of the new surface of red earth. During a portion of this time the layer of stalagmite in the Vestibule appears to have been either absent or broken through, for man ate his feasts and left his refuse to accumulate, so as to form the black band. Subsequent to the formation of the black band it was covered with stalagmite. If such events occurred, is it not possible that the objects of human workmanship may have been introduced into the cave earth during its rearrangement, and that this earth may have already contained the bones of animals which had died long before? The fact that the bone tools are in the same condition as the bones of these animals is a difficulty, but it does not appear to be decidedly opposed to the view suggested. But even if it can be proved that both tools and bones were introduced at the same time, the rolled condition of the bones, and the derivation of the red earth from districts outside the cave, suggests that we have yet to prove that the bones are those of animals who died shortly before the introduction of the red earth into the cave. The black mould above the stalagmite does not seem to indicate a greater antiquity than 2000 years ago. The black mould is a feature which is not met with in the hyæna den at Wookey Hole.

In connection with these two West of England caverns may be mentioned a third, named the Oyle, about which, however, our information is very vague. It is situated in the carboniferous limestone which forms the northern boundary of the great plain in which Dawkins supposes the oxen and horses of the hyæna den disported. Like Kent's Hole, it is 70 feet above the bottom of the valley; like it, it consists of a series of large chambers connected by narrow passages, and like it the uppermost surface consists of a black earth about three feet deep. It bears traces, however, of having been once covered with stalagmite. It contained numerous imperfect chips and flint cores; some of the chips were of a green opaque chert, and others of flint. There were remains of *Ursus spelæus* and other animals whose names are not stated, as also numerous shells of edible molluscs.

On the opposite side of the same bay in which Kent's Hole is situated is another celebrated cavern, that of Brixham, which has likewise been the subject of careful investigation, but we believe no detailed report concerning it has been published. The deposits consist of first, and lowermost, a layer of rounded gravel, followed by an osseous earth filled with comminuted shell in its lower, and a limestone breccia in its upper portion, the whole being covered by an irregular layer of stalagmite. The organic remains belonged to the cave bear, cave hyæna, tichorhine rhinoceros, rein-deer, and species of horse, ox, and deer. Some of these were found in the gravel, but most in the red cave earth. They were associated with flint instruments, one of which was found close to the bones of the left hind leg of a cave bear, the positions of which indicated that the leg was introduced with the ligaments still connecting them. This fact is frequently cited as a proof of the contemporaneity of men with the cave bear.

The grotto of Maccagnone in Sicily is another illustration of the changes which the contents of caves have undergone, and although it is not known to contain remains of *Ursus spelæus*, yet it appears to have a claim to as great an antiquity as those already mentioned. It contained flint implements, bones of *Elephas antiquus*, hyænas, a large species of *Ursus*, a species of *Felis*, probably *F. spelæus*, and numbers of hippopotamus. Many of these objects were found in a breccia, patches of which still adhered to the roof, showing that the cave had once been filled with it, and that subsequently the greater portion had been cleared out again. Dr. Falconer, who examined this cave, remarks that the presence of so many hippopotami imply considerable alterations in the physical configuration of the country. He believes that the cave was chiefly filled by material washed in from above, and that the uppermost was a breccia of shell, bone splinters, burnt clay, bits of charcoal, hyæna's coprolites, and other objects such as are still to be found adhering to the roof. There were large *Helices* whose shells were so perfect as to indicate that the results were produced by the tranquil agency of water, and not by tumultuous floods. He calls especial attention to the inferences that the cave was filled up to the roof within the human period, so that a thick layer of bone splinters and the other objects mentioned was agglutinated to the roof by the infiltration of water holding lime in solution; and that subsequently, and within the human period, such a great change took place as to result in the partial evacuation of the cavern.

The grotto at Aurignac is one of the most important that has yet been explored, as the facts yielded by it appear to us to tell far more strongly in favour of the existence of man with the cave bear than anything we have yet noticed. It is situated on the slope of a hill bounding the valley through which the small brook of Rodes passes, and about 64 feet above it. Apparently it is a simple arched cavity near the summit, without any decided indications that it has been formed by water, and without any connections with other chambers by narrow passages, or with the surface of the ground by fissures. Its greatest depth was seven feet four inches, and the maximum height about eight feet. In front of the entrance there is a depressed platform, the floor of which has been rendered even by pieces of the rock of which the hill is composed, and slabs of a thin fissile sandstone, the nearest locality for which is some hundreds of yards distant on the opposite side of the Rodes valley. On the even levelled floor is a layer of ashes, charcoal, and carbonized bones, from six to eight inches thick. A thick deposit of loose earth and fragments of rock containing numerous bones and tools overlies this, and forms the only continuous layer in the grotto itself. The entrance of the grotto was originally closed by a large slab of stone, but it is not known whether it rested on the mass of loose earth, or penetrated through it so as to rest on the solid rock. In the grotto there were numerous skeletons, but very few notes were made respecting their peculiarities. The cave and platform were entirely hidden from view by a thick talus of rubbish which formed the external slope of the hill. The mass of black earth was evidently a place where the food was eaten, since both the bones and stones showed traces of the action of fire, and charcoal is abundant. The organic remains consisted mostly of teeth and fragments of bones belonging almost wholly to herbivorous animals. The bones had been broken, apparently by human agency, for the sake of the marrow, and even marked with cuts and scratches such as might have been made by flint implements. Hundreds of flakes were found amongst the ashes, and amongst them a round stone with two hollows for the fingers to fit into them, with which the flint implements were made. There were numerous tools of reindeer and roebucks' horns, some fragments of elephants' molars, and coprolites of hyæna. The presence of the latter animal appears also to be indicated by the markings on the bones resembling those of a carnivore. These marks were, however, only found on the bones outside the grotto, those in the interior being perfectly preserved. The animals found in and outside the grotto were :—

Hyæna spelæa. Frequent.
Felis spelæus. Rare.
F. catus ferus. Rare.
Ursus spelæus. Frequent.
U. arctos? Rare.
Meles taxus. Rare.
Canis lupus. Frequent.
C. vulpes. The most abundant species.
Elephas primigenius. Very rare.
Rhinoceros tichorhinus. Rare.
Equus caballus. Abundant.
E. asinus? Rare.
Sus scrofa. Rare.
Bison europæus. Abundant.
Megaceros hibernicus. Rare.
Cervus tarandus. Abundant.
C. elaphus. Rare.
C. capreolus. Frequent.

Under Man, E. C. S., remarks will be made as to the bearing the facts have upon the question of the antiquity of the human race; facts which M. Lartêt thinks gives this old sepulchre a claim to a very high comparative antiquity. His opinion is, however, principally based on the presence of the great cave bear. His views are more explicitly stated in the following sentence:—"The great cave bear, which we there behold evidently contemporary with man, has not, so far as I know, yet [in 1861] been found in France in the diluvium. It is true that it has been mentioned in a list which has been repeatedly reproduced, of the fossil mammals which have been discovered in the diluvial beds of Abbeville; but I have in vain tried to get at the source of the methodical determination upon which this statement rests, and from all that I have seen of its fossil remains, the bear, either from the valley of the Somme, or from the environs of Paris, belongs to a species, or more than one species, very certainly distinct from *Ursus spelæus*. In the centre of France and in England, all the remains of the latter species, not found in caverns, come from deposits regarded by geologists as more ancient than the diluvium. It will doubtless be objected to this that the remains of *Ursus spelæus* occur very abundantly in most of the caverns of the continent, and even in some of those in England; but, at the same time, it must not be forgotten that the date of the filling of these caverns is evidently to be placed beyond the epoch assigned by geologists to the diluvial phenomena, because in several of these caverns, at any rate, the remains of mammals are met with, which are sometimes included in the lists of species referred to in the latter phases of the tertiary period. We see then, that if we rely solely upon the consideration of the palæontological concomitances the result we should arrive at would be that the sepulchre of Aurignac should be referred, together with all the circumstances attending it, to an epoch anterior to the diluvium properly so termed." (N. H. Rev. 1862, p. 71). If then these conclusions are to be accepted, this grotto should be considered to be of nearly the same age as the hyæna den at Wookey Hole, since both contain almost the same assemblage of species, and both yield similar tools; and if the presence of the cave bear is so important a clue, most of the caves, such as Brixham, Kent's Hole, La Roque, Pey-de-l'Aze, the caverns at Liège explored by Schmerling, Maz d'Azil, Trou de Chaleux, Trou Frontal, Trou de Praule, Arcy-sur-Cure, Balot, Echenoz, Fouvent, Osselles, Goudenans, Sentenheim, L'Herm and Neander, should be considered to date their commencement as deposit accumulators from preglacial times. The cave at Arcy-sur-Cure is about 28 feet above the level of the river, and consists of a magnificent suite of lofty halls connected by narrow passages having a length from one end to the other of nearly half-a-mile. The soil on the floor consists of, in descending order, a sandy clay very similar to ordinary loam which contains the remains of the fox, badger, and other recent species; next a reddish breccia of limestone fragments, bones of reindeer, &c.; and lowermost a layer which fills up all the irregularities of the solid floor of the cave, and in which are the bones of *Ursus spelæus*, *Hyæna spelæa*, *Rhinoceros tichorhinus*, *Bison europæus*, and *Equus adamiticus*. In this lowermost bed and in contact with the bone of a cave bear a human jaw bone with two molar teeth, which M. Vibraye states is not accompanied by any circumstance which offers any indication that it has been accidentally introduced. Here then we have a fact analogous to what the committee for exploring Kent's Hole so much wished to find there. This cave is the first we have mentioned which shows the succession of species well defined. The cave bear is confined to the lowest stratum, and the reindeer does not ascend above the third. Amongst the caves which have strata characterized by the presence of the mammoth and the tichorhine rhinoceros and the absence of the cave bear, may be mentioned Le Moustier, Laugeriè, Trou de Chaleux, Maz-d'Azil, Trou de l'Hyene, Trou de la Naulette, Caves, Chalonne, Coudes, Piplart, Baudeans, and Aurensan, but as these layers are not marked off in any very striking way from the others, and as there are few important conclusions to be drawn from their consideration, we pass on to another extensive and highly interesting group of caves, or those which are supposed to have been inhabited during the reindeer period. So far as we have been able to ascertain, none have been recorded in England, and the great majority of those described occur in France and Belgium. The cave of Eyzies is situated in the limestone escarpment by the side of the valley of the Beune, and is more than 100 feet above the bottom of the valley. The floor is covered with an osseous breccia, and this is overlain with a black incoherent mould. The breccia is composed of a mixture of broken bones, flints, some of which have been worked and others not, and other objects cemented by a matrix of carbonate of lime. The flint flakes and flint nuclei from which they have been splintered occur in profusion. The long bones have been split longitudinally, and generally bear marks of a cutting instrument. They show that the reindeer, the horse, the chamois, the common stag, and the Irish elk, have all been used as food by the reindeer folk; but no traces were detected of the dog, the sheep, the hare, or the boar. Without particularizing the contents of each cave in succession in order to show that they pertain to a particular period, a few general remarks will give a slight idea of the people who lived in them. The stone implements are abundant in all the caves, and comprise flakes, scrapers, cores, awls, lance-heads, hammers, and mortar stones. Amongst the tools, found in Le Moustier cave is one elaborately worked, and of a short oval form, which has a marked resemblance to one found in the hyæna den at Wookey Hole. Amongst all the Dordogne specimens not one has been found polished, a fact which may be of some importance in connection with the fragment of polished celt found in the cave earth of Kent's Hole. Bone tools also are numerous; they consist of awls, plain or barbed arrow heads, polished needles with well formed eyes, pins, &c.; but no metal or pottery has been discovered. All these circumstances imply a primitive race of people, yet we find numerous very fair drawings and sculpturings cut or sculptured on bone which have been executed by them. Notwithstanding this comparatively high artistic skill, there seems to be so much resemblance in some of the tools and in the general conditions of life between the cave-bear men and the reindeer folk that it is hard to believe that the one lived in preglacial and the other in postglacial times. In the article MAN we shall have occasion to make further allusion to the reindeer folk of France.

M. Garrigou has arrived at some important conclusions with respect to the French caves, which are expressed in the following translation of a summary given by himself in a pamphlet entitled 'Étude comparatif des alluvions quaternaires anciennes et des caverns à ossements des Pyrénées et de l'Ouest de l'Europe au point de vue géologique, paléontologique et anthropologique.' Paris, 1865. All caverns are far from containing the same species of animals, and experience has taught me, as I, in conjunction with my friend M. Louis Martin, first announced in April, 1864, that in the Pyrenees the level of a cavern relatively to the bottom of the neighbouring valley will enable one to predict the nature of the fauna that will be found in it. I propose to prove, then, that the opinion broached in the note on the cave of Espalungue (Basses-Pyrenees) is supported by evidence since acquired. The caves whose faunas are wholly or in part composed of *Ursus spelæus*, *Felis spelæus*, *Rhinoceros tichorhinus*, *Elephas primigenius*, &c., generally occupy the highest points above the valley bottoms in the limestone of the Pyrenees. Thus in the department of the Ariége the cave of Bouicheta is situated about 700 feet above the level of the Ariege at the iron bridge of Aurignac; the cavern of Enchantées is nearly on the same level. The cave of Lherm is at least 615 feet above the Ariége at Foix; the cave of Loubens or Portel is more than 770 feet above the Ariége at Crampagna; the upper cave of Massat is 554 feet above the Arac brook; that of Aubert in the Castillonnais is 740 feet above the Lez rivulet. Several other caves of Ariége and Haute Garonne, which I have not described yet, and which also contain relics of the cave bear, are from 616 to 770 feet above the nearest river. Some of the caves which M. Philippe has described at Bagnères de Bigorre contain *Ursus spelæus* and the remains of species which are always associated with it. Lastly, the grotto of Aurignac, celebrated as much on account of the illustrious palæontologist who has described it, as from the quaternary fauna which it contained, is situated very high in the limestone group of hills at Aurignac, and far beyond the reach of any diluvial phenomena, as M. Lartêt has justly remarked. The caves in the lower parts of the valleys do not contain the large extinct mammalia found in thcse at great elevations. The levels of the caves in the Bagnères de Bigorre valley apparently contradict this assertion; but a careful study of the locality, aided by the palæontological examination made by M. Phílippe, shows that it is in perfect harmony with the law I wish to establish. A recent movement of the ground has doubtless produced those alterations of level which I shall have occasion to describe in my general studies on the Pyrenees. These alterations of level do not hinder us from still distinguishing in the limestone mountain of Bagnères de Bigorre the caverns which are characterised by the *Ursus spelæus* fauna from those in which the reindeer is the principal mammal, and in which there may also be noticed the absence of the elephant and rhinoceros. The reindeer, then, is the characteristic species of the lower caves, such as that of Bize, near Narbonne; the lower Massat cave, that of Maz-d'Azil, and probably that of Montesquieu Avantès in the Ariége; the caves of the Bédat group of hills (Es-Taliens quarter) near Bagnères de Bigorre in Haute Garonne; that of Lourdes in Hautes Pyrenees; and that of Espalungue in Basses-Pyrenees. We also find in the valley bottoms caverns in which abundant remains of domesticated animals have been discovered. The time when these were inhabited by man belongs to the archeo-geological period, corresponding to that of the lake dwellings of Switzerland, or, in other words, to the Neolithic or polished-stone age. The caves of this kind which we have been the first to describe in conjunction with M. Filhol are those of Bédeilhac, Sabart, Niaux, Alliat, Ussat, Lombrive, Fontanet, &c., in the Ariége. The caves of Pontil and Mialet in Aude and in Gard have yielded to M. Paul Gervais archeo-palæontological remains which belong to the same pre-historic period. In common with other observers, I have noticed that the same cave may contain the several faunas which I am about to name; but then the oldest, or that which accompanied *Ursus spelæus*, occur in the lowest deposits, while the layers above it contain faunas of a relatively more recent period. Thus the Aurensan cave, near Bagnères de Bigorre, has yielded in the ferruginous argilo-calcareous beds *Ursus spelæus*, *Felis spelæus*, *Elephas primigenius*, *Rhinoceros tichorhinus*, &c., above which was a loose dry layer with the remains of species still existing in the locality. In the lowest beds at the entrance of the upper cavern of Massat were *Ursus spelæus*, *Felis spelæus*, *Hyæna spelæa*, &c.; the upper beds containing, as I have already mentioned, remains of the polished-stone age; and there have also been found there metal instruments of comparatively modern date. In the oldest and lowest deposits of the Maz-d'Azil cave there have been found abundant remains of *Ursus spelæus*, *Felis spelæus*, *Hyæna spelæa*, *Elephas primigenius*, *Rhinoceros tichorhinus*, &c. Above this fossiliferous deposit, composed of an argilo-calcareous loess, there is another quite different, formed of sand and pebbles, in which occur bones of reindeer, several species of horse, sheep, ibex, ox, &c., to the exclusion of the animals of the underlying beds. Animal remains belonging unquestionably to a still more recent period, to pre-historic time, overlie the beds with reindeer bones, and are never mingled with the remains of this last-mentioned mammal. In the Pontil cave M. Paul Gervais has found, in the lowest beds, *Ursus spelæus*, *Bos primigenius*, *Rhinoceros tichorhinus*, &c., while the superficial layers indicate the Neolithic or polished-stone age. If on the one hand we pass in review the higher caverns of the Pyrenæan valleys, we shall find that it is mainly formed by the following species: *Ursus spelæus*, *Ursus priscus*, *Felis spelæus*, *Felis sp.*, two-thirds smaller than the preceding, *Hyæna spelæa*, *Hyæna sp.*, undetermined, but probably the same as that now existing in Africa, *Rhinoceros tichorhinus*, *Elephas primigenius*, *Megaceros hibernicum*, *Cervus elaphus*, *Bos primigenius*, *Bison europæus*, and sometimes *Cervus tarandus*, &c. If, on the other hand, we examine the old post-pliocene deposits of the Pyrenæan valleys from a palæontological point of view, we shall find that they contain the same species as the higher caverns, with the exception of the smaller species of *Felis*, and the second species of hyæna which I had already noticed in 1862, which Dr. Falconer also found in the district, and which will doubtless turn up in the valley deposits also before long. The memoirs of MM. Noulet, Leymerie, and others, on the valleys of the Adour, Baizé, Gers, Garonne, Tarn, Salat, Ariége, and Aude, have revealed to us the fauna of these valleys, and enabled us to assert that objects of human fabrication have also been found in the old post-pliocene deposits. We are warranted, then, in saying that the fossiliferous muds of the Pyrenæan caverns, situated from 460 to 770 feet above the valley bottoms, the lower beds of the caverns situated low down in the valley, as well as the older post-pliocene deposits of the sub-Pyrenæan basin, all belonged to the same period, since they all contain the same extinct species. As to the species which accompany the reindeer, and which occur in the caves above the beds with *Ursus spelæus*, it is difficult to assign their special place in the post-pliocene deposits, since they are rarely found in them. As I have said, they characterise certain caves situated in the lower parts of the valleys, and consist chiefly of *Cervus tarandus*, *Megaceros hibernicus*, *Cervus elaphus*, *Bos primigenius*, *Bison europæus*, sheep, chamois, ibex, wolf, fox, and a species of *Canis*, intermediate, probably, between the last two, the lynx, &c. No domestic animals have yet been found. In the beds overlying those with reindeer, and at the entrance of the caverns, we find the fauna of pre-historic times, consisting of *Ursus arctos*, three domestic oxen of the races named *primigenius*, *frontosus*, *brachyceros*, the goat, sheep, *Sus scrofa palustris* domesticated, *Sus scrofa var. ferus*, the stag, the ibex, the chamois, the wolf, fox, domestic dog, hare, blackcock, magpie, jay, &c. This fauna has only been observed in the recent fluviatile deposits of the Pyrenæan regions. It is only in such formations that we can find domestic animals, for reasons which every geologist will readily understand. Moreover, it is only in the beds of the Somme that M. Boucher de Perthes has found the bones of pre-historic animals; the recent peat-bogs have also furnished him with numerous remains. The remarkable, useful, and difficult works executed along the Seine for the purpose of inserting the weirs, have also afforded to their constructor, my friend M. de Lagrenay, civil engineer, a rich collection of pre-historic objects and animals, found in the recent fluviatile alluvium. In the same deposit, my friend M. Edouard de Villiers, civil engineer, has found, while constructing the magnificent bridge of Auteuil, numerous relics of the prehistoric fauna buried deeply in the actual bed of the Seine. If stratigraphy and palæontology indicate three distinct epochs, from the commencement of the post-pliocene period to historic times, the study of the result of human industry so constantly associated with these faunas confirm the accuracy of the divisions. In fact, the caves in which exists the *Ursus spelæus* fauna (Lherm, Bouicheta, Enchantées, Upper Massat, Aubert, Loubens, Maz d'Azil in the Ariége; Minerva, Lunel Viel, &c., in Languedoc; Aurignac in Haut Garonne, &c.), afford facts which warrant the statement that at the time when they were inhabited man was contented with rudely fracturing the bones of the animals whose flesh he devoured, in order to convert them into rough and ready weapons, such as arrow-heads and lances, worked jaws, &c. He also made implements like those found at Abbeville. The author adds notes relating to the Lunel Viel and Aurignac caves. Of the first he remarks that contrary to the prevailing opinion it has contained, and no doubt still contains, splendidly worked quartzites. In a note from his friend M. Ramès, it is said, "I have given a worked quartzite to M. Lartêt. This specimen came from the collection of the Abbé Lavergne, vicar of Arpujon, who obtained it from M. Calmette. The last named, while studying at Montpellier, visited the cave with his companions, and there collected the worked quartzites." Of Aurignac he says:—"This cavern, described by M. Lartêt, our illustrious countryman, has, in my opinion, been the dwelling and burial place of man for a long period of time, or from the age of the cave bear to that of the reindeer. This seems to be proved by the fauna and human tools which have been discovered there. It appears, as I have said above, to have been beyond the reach of any flood of water which could have filled it with deposits. In the caves where the reindeer prevails, Espalungue, Lourdes, Bagnères de Bigorre, Massat-Inferieure, Maz d'Azil, Bizé, &c., the flint implements are more elaborately worked than those of the earlier deposits, the bones and stags' horns are finely pointed, and converted into arrow heads, needles, &c. At a subsequent period, when the cave men already possessed numerous domestic animals, but were ignorant of the use of metals, the bone tools were better finished, the rocks were not chipped, but polished, the art of pottery had acquired considerable development, and, in short, civilisation had made a decided advance. These are the conclusions to be drawn from the researches of myself and others in the caves of Maz d'Azil, Bédeilhac, Castle Andry, Sabart, Niaux, Alliat, Ussat, Espalungue, Pontil, Mialet, &c.

The above facts will, I believe, justify the conclusion, without being far wrong, that in Central France we have traces, in the time which elapsed between the commencement of the so-called Quaternary epoch up to that of exclusively historic times, of three distinct phases in the palæontological history of this period, as well as in the history of the peoples who have lived during the same time. (1) In the first phase man was the contemporary of the cave-bear and of all the animals which accompanied it. The bones of these animals occur either entire or broken by man in the old post-pliocene deposits of the sub-Pyrenæan valleys, in the caverns situated from 616 to 770 feet above the level of the present valleys, and in the lowest beds of the caves with several fossiliferous zones. The relics of human industry which we find mingled, without re-arrangement, with the extinct mammals, indicate a nascent art very similar to that of Abbeville. (2) During the first phase the great carnivora and pachyderms mostly died out. A ruminant, the rein-deer, which already existed in the preceding period, now found itself under such circumstances that its species acquired a rapid development. It had become, by its abundance, the main feature of the second phase, during which man knew nothing of domesticated creatures. Human industry had made a sensible progress; the flint implements were chipped with artistic skill, the bones were shaped with greater intelligence, since they bear upon them sculptures and drawings. The reindeer and its associated fauna occur in the caves situated near the foot of the mountains, and at lower levels than those with the bones of the cave bear. We also find them in certain caves in the deposits immediately above those containing the mammals of the older post-pliocene beds. (3) The third phase was characterised by a fauna composed largely of domesticated animals, whose remains have been found at the entrance to caves situated at the bottom of valleys, and sometimes in the loose soil overlying those which contain the cave-bear or the reindeer. Man then polished his stone implements and rarely chipped them; he knew nothing of agriculture, and was ignorant of the use of metals. For further details the reader is referred to the memoir itself, and the more especially because the author strongly advocates the great antiquity of human races, and carries man's introduction into Western Europe, as far back as the end of the Tertiary epoch.

Of the many Belgian caves which have been explored of late years by M. Dupont, the most interesting are those named Trou de Chaleux, Trou de Frontal, and Trou de Naulette. The cavern of Chaleux is excavated in the limestone escarpment of the river Lesse, and is about 55 feet above the river level. Its floor is covered with a series of deposits, of which the lowermost are alternating sands and clays, next a bed of gravel, then a bed of sandy clay with angular fragments of limestone. All these occur well within the cave. The gravel is a well marked horizon, as it corresponds to the Ardennais pebble-bed, and consists of small fragments of sandstone and rolled psammite. Two flint knives, believed to be amongst the earliest of the relics of man, have been obtained from it. The sandy clay above it has yielded the remains of *Ursus spelæus*. Nearer the mouth of the cave, and in part extending beyond it down the slope of the hill, are other beds; the first is a band of fragments of carboniferous limestone; next is a bed of sand, dust, and ashes, which is the chief deposit, since it has yielded bones of men and reindeer, together with 30,000 flint tools of all kinds, and the remains of eleven species of mammalia. This is overlain by a band of fragments of carboniferous limestone similar to that beneath it, and is, in its turn, capped by an ordinary yellow clay, which passes up into a reddish clay; and the whole is surmounted by a sandy clay having the general texture of a loess. The eleven species of mammalia alluded to are the reindeer, goat, ox, horse, lion, brown bear, fox, badger, polecat, hare, and water-rat. Nearly all the bones were broken, those of the horse being most abundant, this species having evidently formed the principal supply for the meals of man. Portions of the mammoth were met with, but they were considered to have been used as charms, and to have been obtained in the fossil state. The floor of the Trou de Frontal was also covered with a coarse stratified greenish sand, overlain by the Ardennais pebbles, from which was obtained the tooth of a cave bear. Above this were beds corresponding in character with those of Chaleux. This cave presents features which indicate that it was a burial-place analogous to that of Aurignac. In the Trou de la Naulette have been found a portion of a human lower jaw associated with bones of the mammoth and tichorhine rhinoceros. The caves of Belgium afford an important link in the chain of evidence whereby the probable age of the deposits with the remains of cave bears may be determined, since it appears that in several cases they can be shown to have been formed subsequently to the complete excavation of the valleys, and to be synchronous with the valley gravels and valley deposits; and in no instance is there any decided proof that they are older than the great glacial period. The excavation and filling up of the caves appear to have gone on most actively during the same period as the excavation and partial filling up of the valleys was effected. If on the one hand, then, the remains of certain animals, such as the cave bear, are to be considered as the signs of a very early post-pliocene or late pliocene age, on the other hand we have proof that some of the cavern deposits containing bones of cave bears are not older than the river gravels, and that the contents of those do not indicate a later period than others, the age of whose deposit we are unable to determine by stratigraphical evidence. Looking at all the facts, it seems to us that they are more in favour of the conclusion that man lived after, not before, the valleys were excavated; after, and not before, the great glacial period. For further remarks on the general sequence of post-pliocene deposits, the reader is referred to Post-Pliocene Period, E. C. S. We have reached the limits of our article, but we are far from having exhausted our subject. The cavern of Bruniquel, the contents of which have been reported upon by Professor Owen; the Genista, St. Michael's, and other caverns on the Rock of Gibraltar, which have received the attention of Professor Busk and Dr. Falconer, and which afford most important evidence as to the former connection of Europe with Africa, as well as to the habitation of the rock by multitudes of deer, large *Felidæ*, hyænas, and man, where now there is but scant herbage for even a few goats; the Mnaidra and other breccia filled fissures and caverns in Malta, which add further evidence to convince us that large elephants, hippopotamus, &c., may have formerly rambled from Africa and across the Mediterranean into European territory; the caverns of Brazil and Australia, and many others too numerous to be mentioned, even in this long sentence, will show how rich the subject is.

(D'Archiac, *Leçons sur le faune Quaternaire*; Lartêt, *Comptes Rendus* lviii.; Dawkins, *Q. J. Geol. Soc.* vol. xviii. p. 115; xix. p. 260; Lubbock, *Prehistoric Times*; Dupont, *Bull. de l'Acad. Roy., Belgique*, 2nd Series, vols. xvii. et seq: Garrigou, *Étude Comparitive des alluvions Quaternaires*, &c., 1865; *Brit. Ass. Reports for* 1865, 1866, 1867; &c.).

CELLS [E. C. vol. i. cols. 812—814]. If we could follow each different kind of cell from its origin to its final stage, and could correlate each phase with its associated phenomena, we should write one of the most interesting and most important chapters in the whole range of biological science. Such a task we conceive to be a peculiarly difficult one, owing to the dense imaginative halo which has shrouded the subject. It is asserted that the ultimate element of all organic structures is a cell, that is, a body with dense plastic walls enveloping a space which is usually filled with a fluid; but this position is not beyond dispute, for there are, to all appearance, particles of homogeneous texture without any internal cavity, such as fibres, which cannot be, or at least have not been, traced to cells for their origin. Nevertheless, it is certain there are cells, and it is no less certain that they perform most important functions in animated creation.

Every cell possesses the special qualities of organic beings, in that they grow, develope, and reproduce; and it has been suggested that like the individuals which constitute a species, there is a resemblance between the producers and the produced, and that the cells, which are genetically related, pass through the same change of form and structure, and perform the same functions. If we were to carry on the chain of ideas thus started, we might imagine that as cells correspond to individuals, so cells of the same kind, that is, which perform the same function, correspond to species, and the groups of differently constructed cells which are co-ordinated into complex organs or into complex organisms, correspond to genera or families. As species vary, so we might suppose variations might be detected in cells, and by supposing there to be a specially regulated mode of variation, we might develope an hypothesis of the origin or evolution of cells answering to one or other of the numerous hypotheses which have been propounded in explanation of the evolution of species. This hypothesis has not been established yet, but we expect it will be before long, seeing that the hypothesis of Pangenesis, proposed by Mr. Darwin, is a step in that direction, and seeing that external characters are the conspicuous results of the phenomena which occur in the cells. If, then, we wish to get a clearer insight into the conditions which bring about variations in individuals or species, we must submit the cells themselves to a closer scrutiny. The tendency of physiological inquiry has ever been from that which is evident and easily seen to that which is concealed and of minute dimensions.

The cell has for long been the stronghold of vital force, a force which is supposed to be distinct from all the physical forces known to, or which have been experimented with, by man. What this vital force really is, or whether it is not the cover of ignorance, will only be definitively settled when we have ascertained to what extent the physical forces are capable of explaining cell phenomena. As matters stand at present, we would confidently hazard the assertion that there is as much proof for the coexistence of a vital force with the matter constituting the inorganic world, as with that which forms plants and animals. Thus under Animal Kingdom, E. C. S. col. 67, we stated that plants, animals, and minerals are so intimately connected, that they appear to be parts of the same great scheme, rather than independent members of creation; here we would further say that they are analogous to the organs in an organism. In the organism the parts are manifestly arranged and adapted so as to effect a given object, and this arrangement is attributed to vital force. In creation, as manifested on this globe, the parts are also arranged and adapted for a special purpose, but no one asserts that this is the result of vital force; and yet there is a regulating influence which co-ordinates the parts of creation, as well as the organs of an organism. We have seen no conclusive evidence that there is any force specially confined to living organisms; but our ignorance forbids us from positively asserting there is no such force. We will admit that vitality is concomitant with a special set of conditions, and that we do not know what those conditions are, but we demur to those conditions being associated in any way with vital force. A quartz crystal will only develope under favourable physical circumstances, and an animal is in like manner dependent upon suitable physical conditions for its existence.

Of late years, however, the seat of vital action has been lodged in centres still smaller than the cell. Professor Beale states that a cell is composed of matter in two states. The interior consists of forming, growing, active matter; the exterior of formed matter, or that which has ceased to be active. The forming matter, he says, has inherent powers of changing itself; but the formed has not, the change which it undergoes being due to forces external to itself. His view appears to be, that in the centre of a cell there is a mass of matter which contains a vital force whereby it is compelled to grow, and whereby it is enabled to convert inanimate into animate matter. As we pass from the centre of the cell to the circumference, we traverse matter which approaches more and more nearly to that passive condition which he attributes to the cell wall. Of this cell wall he says: "It may be changed or altered, but it has no inherent powers of compelling the elements of matter to assume certain fixed relations to each other, like the germinal matter. It has ceased to live." He maintains that a cell consists of living matter, surrounded by dead matter; and in order that fresh matter become living, it must traverse the cell wall.

In plants, Mohl maintains that the special seat of activity is in a layer, which accumulates on the inner surface of the cell wall, and which is called the primordial or proto-plasmic utricle; but other botanists have denied that there is any special layer to which the active force is restricted.

The chemical composition of cells does not seem to have been determined. The central portion is frequently called protoplasm, and is referred to as being the same in every cell, whether it pertains to animals or vegetables. Protoplasm, whatever this may be, for we have seen no precise definition of it, is apparently a protein-containing substance whose special qualities are said to be contractility and sensibility. Protein is, so far as we can gather, some hypothetical substance, which has never been isolated, and whose existence is very doubtful. The name has been applied to a heterogeneous compound of an albuminous nature. Protoplasm, then, is not a definite substance, so that it may be applicable to compounds differing widely in composition and in physical properties. The principal albuminoids are albumen, fibrin, and casein, which differ markedly from one another, although all three are mutually convertible. But these are three only out of many albuminoids which probably exist in organisms; and the prevalent opinion of chemists is that these albuminoids are complex compounds in which many of the constituent simpler compounds are identical. If, however, we confine our attention to the three already mentioned, the perusal of any chemical text-book will afford abundance of evidence that these present many modifications either of a physical or chemical nature. The internal portion of cells is therefore not so simple as is implied by the term protoplasm. At present there are few classes of compounds about which chemists know less, than that to which the albumens belong.

The cell wall is also frequently considered to be simple and uniform in composition. Thus in plants it is stated to be composed of *cellulose*, but cellulose is a term, not for any definite compound of invariable composition, but of a class of bodies having a general resemblance of properties, of which the most characteristic is solubility in an ammoniacal solution of oxide of copper. More than this, Frémy asserts that the cell wall is composed of other substances than cellulose. Thus *paracellulose* enters into the cells which form the pith, epidermis, and medullary rays. It is soluble in the above-mentioned solution, but only after it has undergone a special mode of preparation. *Fibrose* enters largely into the woody fibre; it is not soluble in the ammoniated cuprous solution, but it is in strong sulphuric acid. *Vasculose* predominates in the walls of vessels, and is characterised by being insoluble in the ammoniated cuprous solution, in sulphuric acid, and in hydrochloric acid, but soluble in a strong hot potash solution. These appear to be regarded as chemically distinct bodies, but in the absence of rigid analysis, it will be safer to regard this point as doubtful. They may be, as Payen and others suggest, the same chemical substance in different physical states. But whichever view be correct, it is manifest that there are great differences in the cell wall. In animals the cell wall is of an albuminous nature.

Not only are there great differences in the nature of the protoplasm and of the cell wall, but the cells themselves occur under widely different conditions. On the whole, then, we are impressed, not with the simplicity attending the ultimate elements of organic structures, but with their complexity, a complexity which is quite in harmony with the varied results which are produced, and one which it will require much research and patience to unravel; but before attributing anything to vital force, we ought to eliminate everything that cannot be explained by the action of physical forces.

CEPHALOPTERA [SQUALIDÆ, E. C. S.].

CERCARIA [ENTOZOA, E. C. S.].

CERVIDÆ [E. C. vol. i. cols. 840—868]. The Ungulate group of vertebrates to which the family *Cervidæ* belongs is divided by Professor Owen into such as have an odd number and such as have an even number of toes. The odd-toed group, or the *Perissodactyla*, is represented by the one-toed horse, *Equus*; the three-toed horse, *Hipparion*; and the three-toed *Rhinoceros*. The even-toed group, or the *Artiodactyla*, are represented by the hippopotamus, the peccaries, the hog tribe, the camels, the musk deer tribe (*Moschidæ*), the ox tribe (*Bovidæ*), the antelopes, the sheep, the giraffe, and the *Cervidæ*.

Alces malchis.—The most easterly district for this species mentioned in E. C. is Sweden; but it also occurs in greater or less numbers throughout the Amur district, more particularly at certain localities, such as the mountain parts lying along the Amgun, Gorin, and Ussuri rivers. It keeps in the small mountain glens during the winter, and feeds upon the twigs of young trees, such as the birch and alder. In the summer it retires to the colder mountain elevations for the purpose of escaping from the persecutions of flies. In the autumn it frequently wanders into the river, immerses the head beneath the surface, and browses upon the weeds which it has rooted up with its fore feet.

The elk is one of the few cervine species now common to the European and American continents, but formerly its range was more extensive in the latitudinal direction than it is now. Thus during the period of the infilling of many caves, that is, during the post-pliocene period, the elk was the companion of the mammoth, the reindeer, the musk sheep, the tichorhine rhinoceros, the lion, the porcupine, the hedgehog, the Pyrenæan hare, and others, in various parts of Southern France, or in 43° N. latitude. At present it is not known to the south of the 60th degree of latitude in Western Europe, so that since the time of the flint-implement-making cave-folks of the Pyrenæan slopes, this species has retreated 17 degrees from its former habitat. The retreat appears to have been gradual, for elk remains so occur in the lake dwellings of Switzerland that we appear to be able to trace its gradual extirpation in that district (about 46° N. lat.) as we pass from the older to the newer sites. It probably disappeared from Switzerland a short time before the beaver, when the bear, stag, roe, and fresh-water tortoise were diminishing in numbers, and prior to the introduction of the smaller domestic animals. This would correspond to about the 6th century of the present era.

Tarandus rangifer.—The difference in the shape of the horns of the European and North American individuals is indicated in the wood-cuts in E. C. vol. i. cols. 851, 854. Mere differences of form seem to be of little importance as a means of classification; but the general nature of the difference between the two varieties of reindeer is so constant and is so manifestly related to the circumstances under which each lives as to be worth attention. In the Barren-ground Caribou the brow antler forms a broad triangular palmated process, parallel to and almost as long as the face. In the Lapland reindeer the brow antler has not this palmated triangular shape; the main branch diverges at a slight angle from the line of the face, and the projections are curved upwards. The palmated antler of the Barren-ground Caribou is used as a shovel for clearing away snow. The upper portion of the antler is moulded into a sharp point, with which the animal breaks the surface of the hard snow. In some individuals there are two of these shovel-like antlers, while others have one only. Where there are two such antlers they are inclined outwards, so as to act like a double shovel; and where there is one it is almost vertical, but can be used both with the right and the left motions of the head. The horns of the Lapland reindeer are rarely used for removing the snow, and they are evidently far less efficient for this purpose than those possessed by their near allies in America. The foot is the implement chiefly used by them. Andrew Murray has drawn attention to these differences, and urges that they are specific and not varietal. There is certainly a constancy in the difference which lends much support to this view, while on the other hand there is so intimate a relationship between the character of the horn and the surrounding conditions that we might suspect the character was in part developed in consequence of those conditions. Admitting that there is a difference, the question to be solved is, whether the Barren-ground Caribou is a specially distinct creation from the Lapland reindeer, or whether both are not the modified descendants of a common ancestral stock. There is no method of proving their distinct creation, that is, the direct creation of a Barren-ground Caribou without the intervention of parents, and of a Lapland reindeer under the same conditions; the only argument in support thereof is that they are distinct now, and there is no evidence that they descended from parents specifically unlike themselves. The special-creation hypothesis will therefore remain impregnable so long as the evolutionists fail to establish their case. In our opinion neither hypothesis has been proved, but there are fewer difficulties on the evolutionary hypothesis than the other. There are other differences, but these also may be in part due to climatal influences. The North American individuals have yellowish brown hair in summer, and white in winter; in the Lapland individual the winter colour is grey.

If, however, all the varieties of reindeer are introduced into the comparison, the gap between those of America and Lapland is partially filled up. The type prevalent in Spitzbergen closely resembles the American Barren-ground Caribou, especially in the triangular palmated basal snag. The Siberian individuals are intermediate between the Lapland and American deer; the horns are broader than those of the Lapland type, the snags more numerous, and there is a nearer approach to palmation, as indicated in the curved and flattened snags. The Greenland type has horns intermediate between those of the two American varieties.

It is stated by many authorities that the reindeer sheds his horns before the winter sets in, a statement at variance with what has been said above with regard to their uses. Pennant says they are shed soon after September; Hearne and Colonel Smith, who is the authority followed in the E. C., mention November as the month in which they are cast off; but Dr. Armstrong's account is that the bucks shed their antlers in June, and reproduce them in the following autumn. Most of the Arctic deer retain their horns throughout the winter. There is another statement, supposed to be well established, to the effect that the herds retreat from the north to the south on the approach of winter. This is only partially true, since herds have been seen during winter as far north as Arctic voyagers have penetrated. Dr. Armstrong saw them in the Prince of Wales Straits and in the Bay of Mercy, or some degrees north of the northern limits of woods, for two successive winters. Dr. Hayes ('Open Polar Sea') mentions herds of tens and fifties as being met with near Foulkes Fiord, between 78° and 79° N. lat., in October; and he says some herds remain as far north as this throughout the long Arctic night, and that they grow very poor. He met with a large herd in February, when the thermometer was 41° below zero. These facts indicate that we have not yet ascertained what is the northernmost winter limits of this species. The southern limits have been ascertained more definitely; but this has been gradually retiring northwards within the memory of man. Thus thirteen or fourteen years ago herds might be seen in the Fillefjeld of Sweden; but now none exist south of the Namsen river. This northward retreat appears to have been going on for many generations, since rein-deer bones are scattered over Western Europe as far south as 43° N. lat., and in countries where no tradition points to its former existence. But whether it ever extended over the whole area of distribution at any one time is more than we can say. Reminding the reader that the present southern limit is about 60° N. lat., we will notice a few of the localities where the fossil remains occur; and in so doing we shall work our way gradually from north to south.

Latitude 55° and 56° N.—Few specimens have been obtained from Scotland; but these are interesting, as they appear to be of greater geological antiquity than most rein-deer relics. A fragment of the antler of a female was stated by Dr. Smith to have been discovered in a railway cutting near Croftamie, Dumbartonshire; it was associated with marine shells, such as *Cyprina islandica*, *Astarte elliptica*, *Astarte compressa*, and *Littorina littorea*. This would correspond to the age of the glacial marine clays, or a period long prior to that of the carse clays, in which the oldest known traces of man in Scotland have been found. We can, however, mention still older specimens, namely, the horns and skulls which were exhumed from the sand underlying the boulder-clay at Kilmaurs, Lanarkshire.

Latitude 53°—54° N.—Several specimens have been found in the neighbourhood of Dublin. A skull, horns, and a lower jaw were discovered by Dr. Oldham in 1847 at Ballyhela, near Dublin. In 1861 Dr. Carte obtained a fine skull with attached antlers from the Curragh bog, near Ashbourne, Meath county, at a depth of five feet from the surface, and resting upon marl and blue clay. A second antler has been found in Meath. The skull from Ashbourne possesses antlers which, with the exception of some minor details, are very similar to those of the Barren-ground Caribou, more especially as regards the presence of a triangular palmated brow-antler, the function of which was doubtless to shovel away the snow. This specimen is a singularly valuable acquisition, as it demonstrates the former existence of the North American and Spitzbergen types of rein-deer in Ireland, a type, of which, we believe, few fossil remains have been found. Most of the fossil specimens are attributed to the Lapland variety; but it may be hoped that some one will endeavour to trace out the geological history of both varieties, a history which will add much to our knowledge of the post-pliocene period. Remains of the rein-deer are found in a somewhat similar position in Mecklenbourg, that is in the calcareous deposits at the bottom of bogs, in association with relics of the elk and *Bos primigenius*. Their antiquity does not seem to be very great, so that these remains may belong to some of the later representatives of the species in that country, and may have flourished during the period of the more recent inhabitants of the French caverns, and somewhat before the time of the Swiss lake-dwellers.

Latitude 52°—53° N.—The earliest discovered of the Irish rein-deer remains consist of two antlers obtained from the bog of Ballyguiry, near Dungarvan, in 1741, and of some remains from Lough Gur, near Bruff, discovered in 1846. Other antlers have been found at Coonagh, in Clare county. The skull and horn noticed by Professor Owen as having been found beneath a peat-moss at East Bilney, Norfolk, belongs to this latitude, as also a metatarsal bone from the Cambridgeshire fens.

Latitude 51°—52°. N.—Most of the English specimens have been found in this range. Thus a single cave in Glamorganshire yielded more than a thousand bones of this species. Its remains have also been disinterred from the Wookey Hole cave so ably explored by Mr. Dawkins. Here we have the first indication in travelling southwards of the usual mode of occurrence of the rein-deer in its more southern range. The bones either occur in or associated with a reddish earth containing numerous blocks which have fallen from the roof of the cave. The Wookey Hole specimens belong to the varieties usually called *Cervus Guettardi* and *Cervus Bucklandi*, and are associated with *Elephas primigenius*, *Rhinoceros tichorhinus*, and *Hyæna spelæa*. Here, too, we meet with a circumstance better developed farther south, namely, the contemporaneity of man with the rein-deer in all the countries where its remains have been found. Thus some of the antlers in this cave have been wrenched from the skull, not shed. True, a wild beast might have done this, but there are other facts which confirm the assertion that man and the rein-deer lived together, for which the reader is referred to CAVES, E. C. S. The low level gravel of the Wiley valley, near Salisbury, has afforded an interesting group of fossils, for in it are commingled the bones of rein-deer, fox, cave hyæna, cave tiger, *Spermophilus superciliosus* (?), *Lemmus Grœnlandicus* (?), *Lepus timidus*, *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus plicidens*, *E. fossilis*, *E. caballus*, *Asinus fossilis* (?), or a small horse; *Sus scrofa* (?), *Cervus elaphus*, *Bison priscus*, *B. minor*, *Bos primigenius*, *Bos longifrons*; and the eggs of the wild swan. Some of these are highly characteristic denizens of northern climates.

Latitude 50°—51° N.—A cranium from Berry Head cave in Devonshire is mentioned by Professor Owen, and a skull with bones were found in Brixham cave. The most important localities in this range are the Belgian caves explored by Schmerling, Dupont, and others. In these the rein-deer bones are associated in sparing numbers with those of animals characterising the fauna which flourished with the cave-bear, and in surprising abundance in an ossiferous yellow clay, with large rock masses, of more recent age. The clay is designated by Dupont as the *Cervus tarandus* or rein-deer stage. The Abbeville gravels have also afforded rein-deer remains.

Latitude 49°—50° N.—As examples of the localities in this band, the following will be sufficient. Lartêt records it from the post-pliocene deposits at Virey-Nourueil, near Chauny (Aisne), which also contain *Elephas antiquus*, *E. primigenius*, *Rhinoceros tichorhinus*, *Ovibos moschatus*, &c.; and other observers have obtained it from deposits of similar age in the departments of Moselle and Meuse. The cave at Rabenstein in Bavaria has yielded *Elephas primigenius*, *Rhinoceros tichorhinus*, horse, and rein-deer.

Latitude 48°—49° N.—Proceeding still southerly we reach numerous localities in the neighbourhood of Paris where rein-deer's bones have been discovered, such as Étampes, where Guettard obtained the first recorded relic. They are associated with remains of northern forms like *Lagomys*, *Spermophilus*, the hamster, and the aurochs, as also with representatives of the genera *Elephas*, *Rhinoceros*, *Hyæna* and *Hippopotamus*, which are now restricted to more southern latitudes.

Latitude 47°—48° N.—The caves at Arcis-sur-Cure have been repeatedly explored from the time of Buffon in 1740 to that of Vibraye in 1858; but it was not until 1853 that rein-deer remains were detected. In the cave called "des Fées" the soil was arranged in layers; the uppermost was a sandy clay or brick earth with bones of indigenous living animals; next came a red ossiferous earth with large blocks of oolitic limestone; and lowermost a layer with *Ursus spelæus* and its usual associates. The middle layer abounded in fragments of rein-deer bones commingled with implements of flint and rein-deer horn, and remains of fire places. Flint implements and rein-deer bones occur in the Balot cave near Châtillon-sur-Seine, in that of Echenoz near Vesoul, in those near Chalonne, and in several others.

Latitude 46°—47° N.—We can find very few notices of the rein-deer's occurrence in this area; but we may mention the cave at L'Echelle near Geneva, as it indicates that this species existed in post-pliocene times, although no trace of it has been met with in any of the adjoining lake dwellings.

Latitude 45°—46° N.—That the scarcity just alluded to is not attributable to any climatic influence, seems manifest from the abundance of the species in this latitude. Indeed, this, and the regions to the south of it, appears to have been the rein-deer country, *par excellence*. Thus the post-pliocene deposits in the valley of the Po, near Turin, has afforded rein-deer, *Rhinoceros tichorhinus*, *Ursus spelæus*, *Hyæna spelæa*, *Megaceros hibernicus*, *Machairodus latidens*, *Felis spelæus*, and *Trogontherium*. The caves of Dordogne and Charente have yielded thousands of rein-deer bones, but the majority of them are either broken longitudinally for the sake of their marrow, or carved into arrow-heads, fish-hooks, needles, polishers, &c.; or engraved with the likenesses of the aurochs, the rein-deer, the mammoth, and other animals which there is reason to believe then inhabited the district; or sculptured into the form of a nude female; or fabricated into whistles, and other useful articles. These remains occur under circumstances which imply that they belong to the same period, although the time it comprised may have been considerable. They are usually found in an ossiferous red earth beneath one or more layers of stalagmite, and associated with similar objects, many of which have been used for food, such as the horse, a species of ox, the bouquetin, the chamois, fishes and birds. A few of the rein-deer bones present marks so similar to those found on the bones of the same animal, which are daily thrown aside by the Esquimaux of the present day, that we may infer they originated in the same way. Thus the bases of the horns are scratched and nicked, a result which is effected by the Esquimaux in detaching the skin. There are also curious markings just below the cannon bone; similar markings are produced by the Esquimaux in removing the tendons. The rein-deer, in short, was the main resource of the man of Central France, and supplied him with most of his wants just as is the case with the Esquimaux. Proof of this subjection of the rein-deer to man have been found at no less than seventeen different localities in France, yet not one of them have afforded a polished stone implement of contemporaneous date. The localities of this latitude are Pons, Laugerie Haute and Laugerie Basse, Eyzies, Moustier, &c.

Latitude 44°—45° N.—Many of the caves of this region belong to the rein-deer period, and afford similar facts. The more important of them which have contained rein-deer bones are the Bruniquel and Brenges caves. The former contains an ossiferous brecciated layer underlying a capping of stalagmite. The bones belong to the rein-deer, man, tichorhine rhinoceros, antelope, stag, chamois, goat, horse, wolf, dog, fox, fowl, &c. The cave of Brenges contains a reddish ossiferous earth with blocks, and is the one whose exploration contributed mainly to the correct identification of the fossil rein-deer. Previous observers had referred the rein-deer-like bones with hesitation to the Lapland rein-deer, while others considered the differences indicated a distinct species therefrom. In 1837 M. Puel obtained upwards of 200 rein-deer bones from this cave, which enabled him to demonstrate that all the French specimens belonged to one and the same species, the *Tarandus rangifer*.

Latitude 43°—44° N.—Remains of rein-deer are associated with bones of the cave-bear in the caves of Aldene, near Cerseras (Herault), Espalungue, Lourdes, Mas-d'Azil, Aurignac, and other places in the southern departments of France.

Latitude 42°—43° N.—There are several localities on the northern slopes of the Pyrenees, such as the Bize and Massat caves, and the Salat post-pliocene deposits; but, so far as we know, no remains have been found to the south of this range of mountains.

This general survey of the distribution of the rein-deer reveals a state of things widely different from the present, but the change appears to have been effected gradually. No tradition exists in France respecting the rein-deer; it is not figured on any of the old coins; its bones are not found in the most ancient sepulchres in which are frequently buried remains of wild and domestic animals, such as the beaver; it has not been found in any of the peat bogs of France. These facts by themselves, although of a negative character, indicate the great antiquity of the species, and the positive facts already recorded fully support this indication. It is doubtful when the rein-deer disappeared from France or the countries contiguous to it. Cæsar mentions an animal which many scholars believe is the rein-deer, but his description indicates that his knowledge was obtained from the Germans; whether the Germans had themselves seen the animal, or had only heard of it from inhabitants of more northern districts is not stated. In 1357 the Comte de Foix desired to chase the rein-deer, and he went to Scandinavia to find the animal. So far as we can form an opinion, the rein-deer appeared in western Europe at about the same period as the mammoth, and lived in company with it, as well as with several large pachyderms and carnivores long since extinct, but in sparing numbers. When these diminished in numbers or disappeared the rein-deer rapidly multiplied, and became the prominent species. It flourished as the companion of a peculiar race of men who fashioned rude implements, and utilized the rein-deer. In course of time men, probably belonging to a different race or tribe, introduced polished stone implements, but the rein-deer seems to have disappeared before this.

Elaphurus.—In the park attached to the palace of the Emperor of China, near Pekin, are some herds of fine deer of a remarkable character. The Chinese state that they only know the species as represented in those herds, and that its introduction into the park dates from a far distant period, of which no record has been preserved. Several specimens were shot by English soldiers when the Imperial Palace was ransacked some years back, and a few heads were brought to England. Some specimens sent to France by Father David were described by Milne-Edwards, who proposed to make them the type of a new genus, *Elaphurus*. It has a general resemblance in appearance and gait to the rein-deer; in the anatomical features of its skull and the nakedness of its muzzle to *Cervus;* the tail is long, and furnished with long hairs which draggle at the heel like that of the ass. The male only possesses horns, which have no basal antler, but are usually of well-developed proportions, and highly ramified. The process of the frontal bone which supports each horn is longer than in the common stag. The beam is thick, and, at some distance below the burr, gives off a branch almost equal in thickness to itself, which is so horizontally disposed as nearly to touch the animal's back. Near the extremity of this branch, on its outer margin, are a group of antlers which give this part a semi-palmated aspect, like that of the brow antlers of old Lapland rein-deer. The rest of the beam has a double or S-like curve, bears two large tynes directed backwardly and inwardly, and terminates in a fork. The upper part of the horn is beset with a number of tubercles. The hair is rough and brittle, and of a yellowish-brown colour, with the exception of a black band along the centre of the back and chest. Its size is that of a large stag. The Chinese have fully recognised the peculiar combination of characters possessed by it, since they call it the Ssen-pou-siang, or the creature with four inconsistent characters; because, as they say, it resembles a stag in its horns, a cow in its feet, a camel in its neck, and an ass in its tail. The species has been named *Elaphurus Davidianus*.

Cervus elaphus.—Like many other of the *Cervidæ* this species is passing through those preliminary stages which frequently foreshadow its final extinction, the principal of which is restriction to a narrower area. Ninety years ago the last individuals disappeared from Northumberland; in the time of the grandfather of the present Duke of Bedford the ducal hounds were employed in extirpating the species from Devonshire. Formerly it ranged throughout the length and breadth of the British islands, as demonstrated by the distribution of its remains, which are as widely distributed as the widest known range of the living individuals. A century ago it was abundant in a few localities in Ireland; in the ninth century it was generally distributed throughout the island, and, in still earlier times, it would appear to have been abundant, to judge from the numerous bones left by it in and beneath peat bogs. A number of bones were dug up from the bog at Bohoe, Fermanagh County, in 1863, from which two skeletons were constructed, and deposited in the museums of Trinity College, and of the Royal Dublin Society. These indicate individuals rather larger than the individuals usually met with now, and present certain peculiarities, such as 14 instead of 13 ribs, which have induced Professor Haughton to name it *C. elaphus var. fossilis hibernicus*. An antler found in Ballinderry Lake, Westmeath, had 19 points, and also indicated an unusually large specimen. This evidence of the former greater size of the species is met with in the remains found in other parts of the British Isles. Thus, an antler was found in Coldingham churchyard in which the beam just above the burr was 7 inches in circumference, a size rarely met with in modern deer. The past and present distribution of the rein-deer and red deer illustrate a phenomenon especially noticeable in the post-pliocene fauna as compared with the present. It is the former association of species upon the same area which are now disassociated upon different areas. Formerly the rein-deer and red deer coexisted throughout most of Europe, although the red deer extended farther south, as into Spain.

At present the two species are confined to entirely distinct areas. In this case it seems the rein-deer retreated northward, while the red deer has retained nearly its old limits, although far less abundant in many localities. But there is a variety of, or a closely allied species to, *C. elaphus*, viz., *C. barbarus*, which exemplifies the southern retreat. It has recently been discovered in the Genista Cave, Gibraltar, along with the *Hyæna brunnea* of South Africa, the leopard, the lynx, the serval, and the African elephant. This species is now living only in Barbary and Tunis.

C. taivanus, Blyth, is a new species from Formosa, nearly allied to *C. sika*, and frequently alluded to in Chinese poetry as the "red deer with its snowy spots." These spots persist throughout the winter, whereas in most spotted deer they disappear during the cold months.

C. Swinhoii, Sclater, is another species from Formosa, which Sclater says has the general aspect of a rusine deer. The head, neck, and fore legs are greyish-black, growing more rufescent on the back, and passing, on the rump and hind quarters, into a deep chestnut. The tail is rather long, very bushy, and composed of grizzly, blackish hairs. The inside of the thighs and belly beneath are fawn-coloured, passing on the inside of the legs into pale ochraceous.

Dama vulgaris.—James I. may have introduced individuals of this species into Great Britain, but it is certain it lived in these islands many centuries before he reigned. Its native habitat is the regions immediately bordering the Mediterranean—Spain, Sardinia, Italy, Greece, Asia Minor, Syria, Egypt, and North Africa; in other words, it flourishes best at present in warm, but not tropical, districts. It is not probable that it ever existed wild in Norway during the present era. Fitzstephens mentions the fallow-deer as one of the inhabitants of the forest which formerly covered the heights north of London, and remains of it were found in a deposit at Richmond, Yorkshire, the age of which is certainly older than the time of James I., and may be pre-Roman. No well-established traces of the species have been found in the British islands which can be considered older than the Roman advent, and Lartêt is of opinion that the Romans were the first to introduce it into England. It frequently occurs in Roman refuse heaps. The species has been recorded from the Swiss lake-dwellings, but Rütimeyer is now inclined to believe this is a mistake. It can be traced farther back in time in France, for its bones have been obtained from the Abbeville post-pliocene gravel, and called *Cervus Somonensis*; from deposits of similar age in the Limagne and at Velay; and from an osseous breccia at Pedenas, near St. Hippolyte du Fort (Gard). It is unknown in France in the wild state.

It is possible, however, that this species is indigenous to the British isles, for deer of this type occur in earlier strata. The *C. Falconeri* of the Norwich crag, and *C. Brownii* of the Clacton beds are species which have more resemblance to the fallow deer than any of the known species. These species are founded upon horns, and are described by Mr. Dawkins in the 'Quarterly Journal of the Geological Society,' xxiv. p. 516, *et seq.*, from whose papers we quote the following passages, in order to show their relationship with the fallow-deer; and, first, we will take the oldest, *C. Falconeri*:—"The characters presented by this antler are of very high specific value. First, as regards the tynes. The brow-tyne is removed from the base, and in that respect differs from that of *Cervus dama* and *Cervus Brownii*. It is, moreover, situated in a different plane from that of the second and third tynes, and is so far closely akin to that of the French pliocene *Cervus tetraceros* in the British Museum. The second tyne is much smaller, and situated much nearer the first than in the fallow-deer or *Cervus Brownii*; while the third, which strongly resembles that of the latter species, is further removed from the second, the relative positions of the two on the beam being reversed. The beam is flattened as in *C. tetraceros*, but not to so great a degree. The straightness of the beam differentiates it from the three species with which it has been compared, as well as from the rein-deer; the smoothness, the absence of deep wrinkles, and the size differentiates it from *C. tetraceros*. In fine, the antler presents a series of characters which are united in no fossil animal that has yet been discovered. Its flattened form and the development of the third anterior tyne cause its nearest fossil analogue to be the *Cervus Brownii* of Clacton, while among the living *Cervidæ* its nearest representative is the fallow-deer. Its position in point of time, with respect to these two species, adequately represents its place in the zoological scale. It belongs to the class of flat, antlered deer represented by *Cervus dama*, with which it is connected through the medium of *Cervus Brownii*. The small amount of palmation exhibited by the antler of *C. Falconeri* is largely increased in *C. Brownii*, and reaches a maximum in *C. dama*." . . . "The antlers of *Cervus Brownii* are totally unlike those of any existing species, excepting *Cervus dama*, to which they approach so closely that the type specimen was considered by Dr. Falconer to belong to the latter. The basal half, indeed, so nearly resembles the corresponding portion of that of *Cervus dama* that it would be almost impossible to differentiate fragments from which the coronal portion had been broken away. But the resemblance ends at the second tyne. If the series of antlers of *Cervus Brownii* be compared with those of the fallow-deer, which have been reproduced [in the paper] from Professor Blasius's valuable work ('Fauna der Wirbelthiere,' vol. i.), there is this important difference visible: in the former the third tyne is present on the anterior aspect, while in the latter it is altogether absent. With these exceptions, the antlers of the two species are most closely allied [as shown in figures referred to in the paper]. To the objection that the third anterior tyne may have been an accident, it may be answered, that it is to be found in none of the endless varieties of form assumed by the antlers of the fallow-deer, and that it is presented also by a far more ancient cervine species from the Crag of Norwich."

Cariacus Lewisii and *C. macrotus.*—These have been separated by Dr. Gray from *Cariacus* to form a distinct group, *Eucervus.*

CETACEA [E. C. vol. i. cols. 869—915]. In the original article the general classificatory arrangement, as well as many of the details, were derived from Dr. Gray's catalogue of the cetaceans in the British Museum published in 1850. In 1866 a new edition of that work appeared in which were embodied all the improvements in classification suggested by the facts diligently collected by the author during the previous sixteen years. Portions of these researches, however, had already been printed in the 'Proceedings of the Zoological Society for 1864 and 1865.' The principal paper in the earlier 'Proceedings' was devoted to a description of the cetaceans which have been recorded from the seas surrounding the British Isles. A few of the species noticed are from foreign regions, but why they occur in a paper professing to be on British cetacea does not appear, unless it be to show the distribution of the nearest allied foreign species. The author has personally examined nearly all the British species, and on this account alone his descriptions and list of synonyms would be especially valuable. He has carefully compared the homologous bones of each species. He finds that no bone is exactly alike in any two genera; that although the difference is very slight in some cases, so slight as to be inexpressible in words, yet they are permanent and characteristic. In some species, more especially those of the genera *Megaptera*, or *Physalus*, the bones present "a certain amount of variation in minor particulars, yet almost every bone of each species has a character of its own, so that a person conversant with the subject and fresh from the study and comparison, can say at once to which genus or species any bone that might be shown to him belongs, even if it were only a phalange or rib." Impressed with this belief, he uses the characters of the osseous system largely in his specific descriptions; but as it would be impracticable to describe every bone, he selects a few parts only, such as the head of the first and second ribs, the cervical vertebræ, and the tympanic bones, as being the most distinctive. We especially refer to this important feature of the paper because the palæontologist can only classify by means of the characters presented by the hard parts, and because it is very desirable that the results obtained by him should be comparable with those of the onto-zoologist. This can only be done when the latter attaches equal importance to the hard and soft parts as aids in specific distinction, and this is the case with very few zoological classifiers. There is, however, another important feature wanted, not only in cetaceans, but vertebrates generally. It is that the bearing which the variations in the hard parts have upon the functions and forms of the organs should be ascertained and taken into account.

The British seas seem to abound in these huge mammals, but the superiority of this area over that of closely contiguous areas is probably apparent only owing to the more active study of them by British than by foreign observers. The older authors, such as Fleming, Turton, Jenyns, and Bell, only knew of from 14 to 18 species when they wrote their accounts of the British fauna, but in Dr. Gray's paper the number is raised to 30, and two more have since been added; so that the total is 32. In Schlegel's 'Fauna of Holland' (1862), 10 species are enumerated as occurring on Dutch coasts, while Nilsson enumerates 16 Scandinavian species in his 'Skandinavisk Fauna' (1847). The following table is a list of the British species, distinguishing those of Scandinavia by S, and those of Holland by H. :—

Balæna mysticetus. S. H.
Megaptera longimana. S.
Physalus antiquorum. S.
P. Duguidii.
P. Sibbaldii.
Benedenia Knoxii.
Sibbaldus laticeps.
S. borealis.
Balænoptera rostrata. S.
Eschrichtius robustus.
Catodon macrocephalus. H.
Physeter tursio.
Steno rostratus. H.
Delphinus delphis. S. H.
D. Euphrosyne. S.
D. tursio. S. H.
Lagenorhynchus leucopleurus. S.
L. albirostris. S.
L. acutus.
Hyperodon Butzkopf. S. H.
Lagenocetus latifrons.
Ziphius sowerbiensis. H.
Globiocephalus Svineval. S. H.
G. affinis.
G. incrassatus.
Orca gladiator. S. H.
O. crassidens.
Grampus Cuvieri.
Phocæna communis. S. H.
P. spiniferum.
Beluga catodon. S.
Monoceros monodon. S.

The new arrangement of Dr. Gray, an outline of which is subjoined, principally differs from that given in E. C. vol. i. cols. 871—874, in a wider classificatory value being given to the same group of characters, so that what was called a genus is in many cases raised to the rank of a family, and in some cases a family has become a section embracing two or more families. Illustrations will be given in the sequel.

Sub-Order CETE.

This has the same characters and value as before.

Section 1. MYSTICETE.

Palate furnished with transverse fringed horny plates of baleen or whalebone. Teeth, none in adults. Head, large, depressed. Nostrils separate, longitudinal. Gullet very contracted. Tympanic bones large. Lachrymal bone, none. Food, mollusca and fish. This is equal to the family *Balænidæ*, E. C. vol. i. col. 872.

The genera present an interesting gradation in the width of the skulls, and if arranged by this character alone would stand thus, the first-mentioned having the widest. *Sibbaldus*, *Balænoptera*, *Rorqualus*, *Megaptera*, *Physalus*, *Eubalæna*, and *Balæna*.

Family 1. BALÆNIDÆ (=genus *Balæna*, E. C. vol. i. col. 872).

Dorsal fin, none; belly smooth; baleen elongate, slender. Vertebræ of neck, anchylosed. Pectoral fin broad, truncated at the end. Tympanic bone rhombic. Maxillary bones narrow, linear, rounded. Lower jaw with only a rudimentary ramus. Scapula higher than wide, with a distinct coracoid process.

Genus 1. *Balæna*. Type, *B. mysticetus*.—Skull high and contracted behind; the frontal very narrow, marginal, directed backwards; tympanic bone rhombic, large; orbits, small. Baleen, tough, flexible; enamel, thick; internal fibres few, very slender, forming a beautiful thin flaccid fringe; cervical and the first dorsal vertebræ united by their bodies. Blade bone much higher than broad, with a broad acromion. Pelvis formed of three bones. Head about one-third of the entire length. The frontal bone short, broad and band-like, obliquely truncated over the orbit. The upper maxillary bone and intermaxillaries are very narrow, linear. The nasal rather large. The lower jaw is thick and rounded with scarcely any ramus near the base. The pectoral fin moderate, with five short unequal fingers, and a short spur on the inner side at the base of the first finger; the middle finger longest, then the second, then the first; the outer or little finger very short and rudimentary. The first five cervical vertebræ are anchylosed; the sixth free, with rudimentary inferior lateral processes; the seventh without any inferior process. The blade-bone, with three nearly equal sides and a small anterior coracoid process. The lateral process of the atlas conical on the upper part of the sides.

B. mysticetus inhabits the North Sea; and specimens have been seen off Peterhead, Tynemouth, and the coast of Zetland. In 1860 some of its cervical vertebræ were dredged off Bridport, so that possibly it may have formerly extended south of its present limits.

Genus 2. *Eubalæna*. Type, *Balæna australis* of E. C. vol. i. cols. 872, 899.—Skull broad and depressed behind. The frontal bones broad, band-like, transverse. Tympanic bones rhombic, large. Baleen thick, rather brittle; enamel thin; internal fibres numerous, thick, rather intertwined, forming a thick rigid fringe. Cervical vertebræ all united by the neural apophyses into a single crest. Lateral process of the atlas rather broad, rounded, shorter below. Ribs, 15 on each side, the last four pairs not reaching the sternum. Blade-bone flat, higher than broad, with a single prominent acromion. Arm bone stout. Fingers five, short, the middle longest.

There is no British representative.

Genus 3. *Caperea*. Type, *Balæna antarctica*, E. C. vol. i. cols. 872, 899, 900.

Not represented in British seas.

Family 2. BALÆNOPTERIDÆ.

Dorsal fin distinct. Belly plaited. Baleen short and broad. Maxillary bones broad, expanded, sharp edged. Pectoral fin lanceolate. Vertebræ of neck free; first and second rarely anchylosed. Tympanic bone oblong, ovate. Frontal bone flat, expanded, broad over the orbit; orbit large. Scapula broader than high, with or without a coracoid. This family is divided into two sections.

I. *Megapterina*. Dorsal fin low, broad. Pectoral fin elongate with four long fingers. Blade-bone broader than high, with only a small or no coracoid process. Cervical vertebræ often anchylosed. Frontal bone broad, narrowed at the orbital end; orbit moderate. Neural arch high, subcircular. This group is equivalent to the genus *Megaptera* of E. C. vol. i. col. 872.

Genus 1. *Megaptera*. Type, *M. longimana* of E. C. vol. i. col. 872. Pectoral fin elongate, about one-fifth of the entire length of the animal. Dorsal fin low, truncate. Second cervical vertebræ with two short truncated lateral processes. First rib simple headed, without internal process. The upper maxillary bone is rather broad with a convex outer margin; the intermaxillaries are moderately broad; the nasal very small. The frontal bone is broad, much and gradually narrowed, and contracted over the orbit. The lower jaw slender, subcylindrical, with a compound ridge-like ramus near the base. The atlas with an oblong body, and with a large and short broad lateral process from the upper part of each side. The upper and lower lateral processes of the second cervical vertebræ very thick, short, blunt, and separated at the ends; of the other cervical vertebræ slender, more elongate, separate. Neural arch of the cervical vertebræ strong, high, with a large subcircular cavity for the spinal marrow. The bodies of the cervical vertebræ oblong, roundish, or subquadrangular, rather wider than high. The scapula short and broad, without any, or a very small, coracoid process. The arm bone long; wrist with a broad flat spur; the fingers, four, elongate, very unequal in length, the third longest, the second rather shorter, the fourth much shorter, and the first shortest; the longest is formed of eight joints. The front ribs thick, oblong, compressed without any swelling or compressed dilated part near the condyle.

Sub-genus 1. *Megaptera*. Type, *M. longimana*.—Blade-bone without any coracoid process; the body of the cervical vertebræ oblong, subcircular. A young female of *M. longimana* was taken in the estuary of the Dee in 1863.

Sub-genus 2. *Poescopia* (Type, *Megaptera Poescop* of E. C. vol. i. cols. 872, 900), is the name given to a sub-genus in which the blade-bone has a small coracoid process, and in which the body of the cervical vertebræ is nearly square with the angles rounded. This sub-genus is confined to the seas of the southern hemisphere.

II. *Physalina*. Dorsal fin erect, compressed, falcate. Pectoral fin moderate, about one-eighth of the entire length of the animal; fingers short, phalanges few; scapula broad, with a long coracoid process; the neural arch broad, low, much broader than high.

a. The dorsal fin, about two-thirds the entire length from the snout; cervical vertebræ free.

Genus 2. *Benedenia*. Type, *B. Knoxii*=*Physalus* (*Rorqualus*) *boops*, E. C. vol. i. cols. 872, 900.—Second cervical vertebræ with two short truncated lateral processes; first rib simple headed, with a compressed internal process. Pectoral fins moderate;

dorsal fin falcate; skull rather broad; maxillæ broad, with nearly straight outer margins. The second cervical vertebræ with two separate, broad, strong, nearly equal-sized lateral processes which are rather expanded and truncated at the top (as in *Megaptera*). The third, fourth, fifth, and sixth cervical vertebræ with elongated slender upper and lower lateral processes, which are attenuated and separated at the ends (not forming rings). The bodies of the cervical vertebræ oblong, transverse; the canal of the neural arch low, oblong, transverse, much wider than high. The scapula short, broad, with a strong, well marked coracoid process. Vertebræ 60. Ribs 15, all simple; the front ones compressed and dilated at the end; the first with a broad rounded lobe on the inner side; the second with an elongate, slender, rounded, internal process. This has been found once only on British shores, as has already been mentioned in E. C.; but it has probably been met with also on the coasts of France and Spain.

Genus 3. *Physalus.* Type, *P. antiquorum* of E. C. vol. i. cols. 872, 900.—Pectoral fin moderate. Dorsal fin falcate, three-fourths the entire length from nose. Cervical vertebræ all free; the second with a broad expanded lateral process with a large hole in the upper part of its base. Tympanic bone oblong, elongate. Vertebræ 54—64. First ribs simple, compressed, not divided, with a compressed internal process near the condyle. The upper maxillary bone is rather broad, gradually tapering, with a straight outer edge; the intermaxillaries are moderate, and the nasal very small. The frontal bone is broad and short, suddenly narrowed on the outer side, and truncated over the orbit. The lower jaw slender, arched, with a distinct elevated ramus near the base. The atlas with a subcircular body; the lateral processes cylindrical and near the middle of the side. The cervical vertebræ posterior to the second have two lateral processes which are often united at the end into a more or less broad ring. The body of the cervical vertebræ is oblong, transverse, broader than high. The neural arch is long, with an oblong, transverse canal for the spinal marrow, which is much broader than high. The scapula high, with a broad coracoid process near the joint.

* The upper and lower lateral processes of the third, fourth, fifth, and sixth cervical vertebræ elongate, united, forming a ring; the body of the cervical vertebræ oblong, transverse, much wider than high; the upper and lower edge nearly straight; the lateral process of the second cervical elongated.

P. antiquorum. Several specimens of this species have been found on British shores, as noticed in E. C. vol. i. col. 900. From the account there given it would seem that two specimens have been taken off North Berwick. The two references apply to the same animal which was captured in 1831. The skeleton there said to be in the Edinburgh Botanic Gardens has since been transferred to the Zoological Gardens of that city, where we believe it is still to be seen. Other examples have been more recently taken. In May, 1859, an adult male was caught in the Hope Reach of the Thames, and its skeleton preserved in Rosherville Gardens. A description of this specimen was given by Dr. Murie in the 'Proceedings of the Zoological Society for 1865.' It was 60 feet long. In the same volume details are given by Mr. W. Flower of a large adult male which was stranded in Pevensey Bay, Sussex, in November, 1865. Its length from the tip of the lower jaw to the end of the tail was 67 feet, the measurement being taken in a straight line. In 1862 an individual was seen in the Frith of Forth near Burntisland; and in the following year another was captured, and its skeleton preserved in Alexandra Park near Wood Green. Several instances are also on record of the occurrence of this whale on the shores of France.

* * The upper and lower lateral processes of the third, fourth, fifth, and sixth cervical vertebræ elongate, slender, free at the ends; the upper one bent down; the lateral process of the second cervical large, truncated. Body of the cervical vertebræ oblong, ovate, not much broader than high; the upper edge concave; the lower very slightly convex.

P. Duguidii. It inhabits the seas in the neighbourhood of the Orkney isles. A long account of the species is given by Heddle in the 'Proceedings of the Zoological Society for 1856.'

* * * The upper and lower lateral processes of the third, fourth, and fifth cervical vertebræ short, strong, separate, directed laterally, the lateral process of the second cervical short, truncated.

P. Sibbaldii. It occurs in the North Sea, and enters the mouths of the larger rivers, such as the Humber.

Genus 4. *Sibbaldus* (or *Sibbaldius*, as Mr. Flower proposes to call it). Type, *Balænoptera laticeps* (Gray).—The pectoral fins moderate. The second cervical vertebræ with a broad elongated process perforated at the base. The front ribs double-headed. Pectoral fin one-eighth the entire length, and the dorsal fin nearly three-fourths the entire length from the nose. Skull very broad, maxillary bones very broad, gradually tapering with nearly straight outer edges. The intermaxillaries moderate, linear. The frontal bones broad, band-like, with a wide sinuous edge over the orbits. Nasal bone small. The lower jaw slightly arched, compressed, with a conical ramus near the condyle. The lateral process of the second cervical vertebræ expanded, with a basal perforation. Tympanic bone oblong, ventricose. The scapula broad, with a large, well-developed coracoid process in front. The hand with four rather short fingers, the second and third equal and longest, the inner and fourth rather shorter than the first. Vertebræ 54. Ribs 13 or 14. The first rib slender, with a process on the side near the condyle, as if the rib was divided into two somewhat similar lobes above so as to be double headed; according to Dubar it is articulated to the first and second dorsal vertebræ.

S. laticeps. This inhabits the North Sea, but the specimens hitherto recorded appear to have been met with only off the coast of Holland and North Germany; species very similar to this have been obtained off the coast of Java. Mr. Flower compared its bones with undoubted individuals of *S. laticeps* from the North Sea, and could detect no specific distinction between them. As, however, the two areas are so widely separated, and the general feeling amongst zoologists is that every species of whale is restricted to comparatively narrow limits, Mr. Flower proposes to consider it a new species, and names it *S. Schlegelii.*

S. borealis. In 1827 a dead whale assigned to this species was found floating in the North Sea, between England and Belgium. It was towed into Ostend, and hence acquired its name of the Great Ostend Whale. Its skeleton was subsequently exhibited at Charing Cross in London, and afterwards transported to the United States. Dr. Gray says it was 102 feet long, while Mr. Flower says it was 87 feet. In 1840 a female, probably a young one, of this species, was stranded at Charmouth, Dorsetshire. Its length was 41 feet.

This section of *Physalina* corresponds to the genus *Physalus* of E. C. vol. i. cols. 872, 900.

b. Dorsal fin two-thirds of the total length from the nose; cervical vertebræ sometimes united.

Genus 5. *Balænoptera.* Type, *B. rostrata.*—Pectoral fin moderate, dorsal fin falcate, vertebræ 50, the last being very small; the first pair of ribs undivided near the condyle; the lateral process of the second cervical vertebra elongate, pierced at the base; of the third, fourth and fifth cervical elongate, slender, separate; the lower with an angular bend below; the front ribs simple, thick, with only a slight swelling on the inner edge near the condyle; tympanic bones obovate, short, ventricose; the lateral process of the second cervical vertebræ expanded, broad, with a large ovate perforation in the middle of its base, the upper and lower margin being broad and of nearly equal width, the upper being if anything rather the broader, and very unlike the lateral process of the same bone in Physalus; the neural arch high, acute, with a rather high subcircular canal for the spinal marrow; the body of the atlas oblong, transverse, with a sub-cylindrical lateral process produced from the middle of the side.

B. rostrata. This is comparatively frequent in the British seas or in the mouths of the larger rivers which flow into them. The specimen taken at Deptford (mentioned in E. C. vol. i. col. 900) is probably the same as that whose skeleton is now in the museum of the College of Surgeons; in 1842 another was captured in the same locality, the skeleton of which is now in the British Museum. In 1834 the species was seen in the Frith of Forth; and in 1860 a male 24½ feet long was stranded at Cromer on the Norfolk coast, and its skeleton transferred to the museum of the College of Surgeons. A description of the Cromer specimen was given by Mr. Flower in the 'Proceedings of the Zoological Society for 1864.' In 1858 a specimen was captured off the coast of Northumberland, and its measurement recorded by Messrs. Mennell and Perkins in the 'Transactions of the Tyneside Naturalists' Field Club for 1864.'

Genus 6. *Eschrichtius.* This was first adopted by Dr. Gray as a sub-genus, embracing such forms as the *Balænoptera robusta* of Lilljeborg. In 1865 he raised it to the rank of a genus, and thus defined it:—

"The external form and size of the pectoral fin, and the position and form of the dorsal fin unknown; lower jaw with a very low strongly developed coronoid process; vertebræ 60; ribs, 15 pairs; the cervical vertebræ free, the body small, thick, suborbicular, quadrangular, rather wider than high; lateral processes of the third to the seventh vertebræ not forming a ring; the canal of the spinal marrow very broad as compared with the width of the body of the vertebræ, and very high, subtrigonal, with rounded angles; the second cervical not known; blade bone with a distinct acromion and coracoid process; arm bones broad, not longer than the humerus; phalange half as long again as broad; the breast bone trigonal, rather longer than wide; front part broad, arched out in front, broadly truncated at the sides; the hinder part at first suddenly tapering for half its length, and then gradually tapering to a point behind." The only evidence of this being British is a single cervical vertebra which was washed ashore at Babbacombe Bay, Devonshire. Dr. Gray says it belongs to *E. robustus.*

Section II. Denticete.

Teeth in one or both jaws, rarely deciduous; palate lined with a hard membrane, without any baleen; gullet large; head more or less depressed; tympanic bones small; lachrymal bones distinct.

Division I.—Nostrils longitudinal, parallel, or diverging, covered with a valve, one often larger and more developed than the other; pectoral fin broad, truncate.

Family 3. Catodontidæ.

Head large, subcylindrical, blunt; lower jaw narrow; teeth large in the lower jaw only, fitting into pits in the gums of the upper one; nostrils separate, one often abortive; the hinder edge of the maxillary elevated, forming a concavity on the forehead of the skull; pectoral fin broad and truncated.

* Head compressed, truncated; nostril in front of the truncated head; dorsal trunk rounded.

Genus 1. *Catodon.* Head very large, one-third of the entire length of the animal.

C. macrocephalus. In addition to the several instances of its having been stranded on the British coasts, recorded in E. C. vol. i. col. 903, may be mentioned the occurrence of a specimen near Thirso in 1863, the skeleton of which is now in the British Museum.

** Head depressed, rounded in front; nostrils in the forehead; dorsal fin falcate.

Genus 2. *Physeter.* Head very large, one-third of the entire length of the animal, rounded, convex above; teeth conical compressed; skull elongate.

P. tursio. This species has been seen on all parts of the coast of Britain, but is much more abundant in the north than in the south, being frequent about the north of Scotland in summer, and rare off the south coast of England and the shores of Ireland.

Division II.—Nostrils united into a single transverse or crescent-shaped blower; head moderate, more or less beaked; teeth in both jaws, one or both sets being often deciduous; the pectoral fin lanceolate, tapering.

Family 4. Delphinidæ.

Head more or less beaked, smooth; teeth simple, cylindrical, conical, smooth; back rounded; dorsal fin distinct, falcated, rarely wanting.

A. Head more or less beaked; beak of the head as long or longer than the brain cavity; bottle-nose. In his earlier arrangment, Dr. Gray made this the second division of what he then called *Delphinina,* as given in E. C. vol. i. col. 904.

a. Pectoral fin moderate, lanceolate, far apart on the sides of the chest; teeth in both the jaws permanent. *Delphinina.*

Genus 1. *Steno.* Definition as in E. C. vol. i. col. 904.

Genus 2. *Delphinus.* Definition as in E. C. vol. i. col. 904.

a. Delphinus. Head with long beak; nose of skull slender, rather depressed, especially in front, much longer than the brain cavity; teeth from 40 to 60 above and below, but by a misprint in E. C. vol. i. col. 909, the number is said to be 100 in each jaw.

* Skull rounded, triangle just to the tooth line; palate with deep groove on each side, and a high central ridge behind. *Delphis.*

D. delphis. It ranges from Greenland to the south of England, and appears on the Cornish coast along with the shoals of pilchards and mackerel.

** Skull flattened behind; triangle to the tooth line; palate flat, not grooved on the side. *Clymene.*

D. Euphrosyne. This has been met with on the coast of England.

b. Tursio. Beak short; nose of skull thick, conical convex above, half as long as the brain cavity.

D. tursio. Ranges from the Mediterranean to the North Sea, and has been recorded from the coasts of France, Belgium, Holland, Scandinavia, and Great Britain.

Genus 3. *Lagenorhynchus.* Definition as in E. C. vol. i. col. 904.

* Beak short; beak of skull only as long as the brain cavity; teeth nearly to the notch.

L. leucopleurus. A shoal was captured in the Orkney Islands in 1864.

** Beak moderate; beak of skull only as long as the brain cavity; teeth not quite to the notch in the beak.

L. albirostris. A specimen occurred off Cromer, Norfolk, in 1866.

*** Beak moderate; beak of the skull longer than the length of the brain cavity; teeth not reaching the notch.

L. acutus. It has ranged as far north as the Orkneys.

b. Pectoral fins small, low down, and rather close together on the middle of the chest; upper jaw toothless, lower with few teeth, sometimes deciduous.

* *Hyperodontina.* Maxillary bones elevated into a crest on the sides behind; teeth two or four, anterior conical; eyes close to the gap.

Genus 4. *Hyperodon.* Forehead convex; gaps short, only as long as the short beak; the eyes near, and the ears far behind the gap; the crest of the maxillary bone thin and wide apart above; the beak of the skull descending downwards; the hinder edge of the skull as high as the crest; lower jaw rather curved; blade bone triangular, with a long acromion and a posterior marginal prominence; the bone of the arm short, fingers short; the opening of the blower is transverse, linear, slightly convex forward in the middle, and slightly bent back at the ends.

H. Butzkopf. This species is one of the commonest of the British cetaceans. It has been taken at Whitstable, in the mouth of the Dee, Belfast Lough, and the Frith of Forth. Formerly Dr. Gray believed there were several British species of *Hyperodon,* but he now thinks they may all be reduced to one.

Genus 5. *Lagenocetus.* The crests of the maxillary bones very thick and close together, especially above, where they are flat topped; the beak of the skull horizontal; the hinder edge of the skull lower than the top of the crest; lower jaw straight.

L. latifrons. Inhabits the British seas. Specimens have been obtained at Moreton Bay, the Orkneys, and in the Frith of Forth. This is the same as the whale mentioned in E. C. vol. i. col. 904, as *Hyperoodon latifrons.*

** *Ziphiina.* Maxillary bones simple; teeth on the sides of the lower jaw, compressed.

Genus 6. *Ziphius.* Lower jaw gradually tapering; teeth on the sides of the jaw of the males large, compressed; and females small, conical; tympanic bones large, very thick, free edge open and much twisted.

Z. Sowerbiensis.

Genus 7. *Aliama.* Head conical, tapering; upper jaw toothless; the lower jaw rather the largest, bent up at the top, with two large conical teeth in front, and sometimes a few smaller on the side just behind them.

A. Desmarestii. It is a Mediterranean species, and the same as those called *Hyperoodon doumetii,* and *H. Desmarestii* in E. C. vol. i. cols. 872, 904.

B. Head rounded in front, not beaked; beak of the skull nearly as long as the brain cavity.

a. Globiocephalina. Pectoral fins falcate, elongate, low down, near together on the chest; head very swollen, intermaxillary bones very wide, covering the maxilla above; teeth conical; side of maxilla expanded horizontally.

Genus 8. *Globiocephalus.*

* Palate of skin flat or rather concave in the middle. *Globiocephalus.*

G. Svineval.

G. affinis. Inhabits the North Sea, but is not known as a member of the present British fauna, although it has been found as a fossil.

** Palate convex; shelving on the sides. *Sphærocephalus.*

G. incrassatus. Habitat, British Channel, Bridport, Dorsetshire. A skull obtained from this place in 1853 is now in the British Museum.

b. Phocænina. Pectoral fin ovate, wide apart, lateral; intermaxillary bones moderate.

† The lateral wing of the maxilla horizontally produced over the orbit; dorsal fin distinct; teeth conical.

Genus 9. *Orca.* Definition as in E. C. vol. i. col. 904.

O. gladiator. In 1864 a school of ten entered the Parrett.

O. crassidens. Inhabits the North Sea, but only occurs as a fossil in Great Britain.

Genus 10. *Grampus.* Definition as in E. C. vol. i. col. 904.

G. Cuvieri. The skull of the Isle of Wight specimen is in the British Museum.

†† The lateral wings of the maxilla shelving down over the orbit.

* Teeth permanent, compound sharp edged.

Genus 11. *Phocœna.* Definition as in E. C. vol. i. col. 904.

P. communis. In 1865 the Zoological Society acquired a fine male porpoise, which was caught off Margate, and which was exhibited in their gardens for a few days. When examined after death the upper edge of the dorsal fin was discovered to be sharp, hard, and serrated, a feature which is present in a South American porpoise, but is absent in the common porpoise. Dr. Gray attaches high importance to the character, and accordingly he employs it as a means of splitting up the genus into three parts, each of which contains one species. What the value of these parts may be, whether specific or subgeneric he does not inform us, and, judging from his general views of the principles of classification, it matters not what they are called. His arrangement is :—

a. Back in front of the dorsal fin, and upper edge of the dorsal fin smooth, without tubercles or spines. Dorsal fin on the middle of the back. *P. communis.*

b. Back in front of the dorsal fin smooth; the upper edge of the dorsal fin with a single series of oblong compressed tubercles which are more crowded near the upper end of the fin. Dorsal fin in the middle of the back. *P. tuberculifera.* Hab. Margate.

c. Back in front of the dorsal fin with a small series, and upper side of the dorsal fin with three series of square based compressed tubercles or spines. Dorsal fin behind the middle of the back. *P. spinipennis.* Habitat, Rio de la Plata.

** Teeth early deciduous, conical, dorsal fin, none.

Genus 12. *Beluga.* Teeth in both jaws early deciduous.

B. catodon.

Genus 13. *Monodon.* Teeth very early deciduous; male with a projecting spiral tusk in the upper jaw.

M. monoceros.

Of the second sub-order, or that of *Sirenia*, there may be said to be no representative in the British fauna. A few specimens of the Manatee have been drifted on to the shores of Scotland and France; but these have been either dead or mere stragglers.

CHABASITE, or CHABAZITE [E. C. vol. i. col. 916]. This is one of the great group of Zeolites, of which it may be said that the species and varieties differ from one another by inconsiderable modifications of a few general properties. Each presents variations, sometimes of such an extent that it merges into the extreme varieties of other species. They appear to occur under similar lithological circumstances, and to have crystallised out under similar conditions. Hence the details relating to one species frequently have a bearing upon the properties and modes of formation of several others.

Chabasite occurs in crystals belonging to the rhombohedral system. The commonest form is a simple rhombohedron, which differs so little from a cube that it has been mistaken for such. The angles at which the principal faces meet are 94° 36′ (but it may vary from this point up to 95° 2′), and 85° 14′; this differs so little from a right angle that an unpractised eye would not perceive the difference. As with the primary, so it is with the secondary forms, many of which simulate or approach to modifications of the cube. Frequently the primary rhombohedrons are united two and two, the crystals being blended together, and arranged around the same vertical axis, but with the lateral axis of the one inclined in the horizontal plane at an angle of 60° to those of the other. This is what, we believe, is meant by the term 'attached crystals' in the original article. A twin structure with a composition face more or less obliquely striated on either side of a median line is a feature which chabasite shares with most zeolites; moreover, we would notice that in quartz blended twins are exceedingly frequent, the pyramidal combination faces are obliquely striated, and that the primary rhombohedron has an angle of 94° 16′, so that it would seem the silica is the predominant ingredient physically as well as chemically. The vitreous lustre occurs in all the zeolites, but varies in its degree of splendour, and in many species the plane of easiest cleavage has a pearly or silky lustre. Pure chabasite is colourless, as indeed are most of the zeolites. Generally, however, the crystals are more or less tinted, which tints are due, not to the inherent nature of the species so much as to the conditions prevalently connected with them, such as partial pseudomorphic alteration, &c. Nevertheless, some species habitually possess certain tints which serve as distinguishing marks. The flesh-red crystals found in Nova Scotia are termed *Acadiolite*, some specimens of which resemble Chiastolite in having the colouring matter arranged in a tesselated manner. When chabasite is treated with hydrochloric acid the silica separates out in a gelatinous condition, and in this respect it agrees with nearly all the zeolites. Under the action of the blowpipe chabasite, like all zeolites, becomes opaque white; but in many other respects the zeolites differ much from one another in their behaviour when treated. Thus some intumesce before they fuse, like chabasite; but others fuse without intumescing, like harmotome. There are also differences in the facility with which the minerals part with or absorb their water of crystallization. Several observations on this point have been published by Damour, but it would be desirable for some one to conduct a series of comparative experiments on the varying force of the chemical affinity of water in hydrated minerals under varying temperatures, both under the same and under diverse conditions. Damour found that crystals of chabasite from Dyrefiord, Zealand, and Rübendorfel, Bohemia, lost 7·2 of volatile matter, probably water only, after an exposure for five months in dried air; and when these crystals had been exposed to ordinary air for a few months they regained somewhat more than they lost. When heated to 100° C. for one hour 2·75 per cent. of their substance volatilized; on raising the temperature to 180° the loss was 14 per cent; at 300° it was 19 per cent.; at a dull red heat it was 21° per cent.; and at a bright red heat the loss was 22·4 per cent., accompanied by intumescence and partial fusion. The higher temperatures effected a radical alteration in the molecular state of the crystals, for those which had been heated to 300° regained their full amount of water on exposure to ordinary air, while those which had been subjected to a red heat were no longer hygroscopic. The variety Phacolite lost 7 per cent. after a seven months' exposure to dried air; but when left in an atmosphere laden with moisture the loss was made good, and an excess of 12·5 per cent. in addition taken up. The excess disappeared when the specimens were restored to ordinary air. At 100° C. the loss was 3·7 per cent.; at 210° 15·7 per cent.; at 290° to 360° 18.per cent.; at a dull red heat 22·2 per cent.; and at a bright red 22·8 per cent., when fusion took place. There is no material difference between the two varieties of mineral. Scolecite contains the same ingredients as chabasite, but in different proportions, the alumina and lime being increased at the expense of the water, of which there is nearly 14 per cent. The crystals lose nothing below the boiling point of water, or 100° C.; at 300° the loss was 5 per cent. or more than a third of all the water; at a dull heat the loss was 12 per cent., and the hygroscopic power was destroyed; at a bright red heat the loss was 13·9 per cent. Chabasite agrees with scolecite in parting with all water at a bright red heat, but the water is retained with slighter force at the lower temperatures. Levynite differs from chabasite in crystalline form, but chemically some specimens of levynite nearly agree with some of chabasite; theoretically the alumina is more abundant in levynite than in chabasite, and the increase in this element is at the expense of the water. One fourth of the water is given off in dried, but reacquired in ordinary air. At 70° C. the water begins to disappear, and at 225° rather more than half has vanished; while at the same temperature much more than half the water is separated from chabasite. Gmelinite, which differs from chabasite in structure rather than in composition yields up its water with greater facility; the loss at 100° C. is 13 per cent.; at 230° C. it is 20 per cent., and at a dull red heat 21·5 per cent. In Phillipsite the structural form is different, as also the chemical composition. The principal chemical difference is that phillipsite contains more potash, which occupies the place partly of the lime and partly of the water. It parts with its water more readily than chabasite; thus a month's exposure to dried air causes a loss of 8 per cent. in the weight, or of nearly one half the water, but this is regained on replacing the crystals in ordinary air for 24 hours; at 50° C. the loss was 12·3 per cent., the whole of which is recovered on placing the crystals in ordinary air, but they disintegrate into an opaque powder. At 150° nearly all the water is liberated, there being a loss of 16 per cent. in the weight; and at 250° C. the whole of it is driven off. In stilbite the proportions of the alumina, lime and water are relatively to each other the same as in chabasite; but the quantity of silica is greater. It parts with the larger moiety of its water more readily than chabasite. At 100° C. the loss is 1·3 per cent.; between 100° and 150° it is 13 per cent., which is not wholly regained on re-exposure to ordinary air; at 170° the loss is 16·2 per cent. Heulandite is chemically like stilbite, but contains rather less water, and in the facility with which the water is liberated it approaches chabasite more nearly than stilbite. Thus the loss in weight is 2·1 per cent. at 100°; 8·7 per cent. between 100° and 150°; and 12·2 per cent. at 190°.

Chabasite, like most minerals, yields slightly different analytical results, so that scarcely any two crystals present the same ingredients in precisely the same proportions. Each ingredient is liable to absolute diminution, the deficiency being supplied by something else. A theoretically pure crystal would contain 47·33 per cent. of silica; 20·3 per cent. of alumina; 11.04 of lime; and 21·3 of water, which corresponds to the formula $Ca\,O.\,Al_2\,O_3 \cdot 4\,Si\,O_2 + 6\,H_2\,O$, to the oxygen ratio 1 : 3 : 8 : 6, and to the simplified expression $Ca : Al.\,Si\,O_3 + 1\tfrac{1}{2}\,H_2\,O$. In most crystals the proportion of silica is in excess of the theoretical estimate, owing, as we suppose, to a partial withdrawal of some of the other ingredients. Generally speaking, the most highly silicated specimens are those which have lost most lime, as is indicated in the following list of analyses, in which the order adopted is the degree of silication :—

	Silica.	Alumina.	Lime.	Soda.	Potash.	Peroxide of Iron.	Magnesia.	Water.
1.	52·20	18·27	6·58	2·12				20·52
2.	52·02	17·88	4·24	4·07	3·03			18·30
3.	52·14	19·14	7·84	·71	·98			19·19
4.	51·46	17·65	8·91	1·09	·17	·85		19·66
5.	50·65	17·90	9·37		1·70			19·90
6.	50·19	17·45	7·13	2·12	·62			22·09
7.	50·14	17·48	8·47		2·58			20·83
8.	48·76	17·44	10·47		1·55			21·72
9.	48·63	19·52	10·22	·56	·28			20·70
10.	48·36	18·62	9·73	·25	2·56			20·47
11.	48·31	19·47	11·01		1·17		·26	19·65
12.	48·18	19·27	9·65	1·54	·21			21·10
13.	47·75	20·85	5·74	2·34	1·65			21·30
14.	47·00	19·71	10·63	·65	·33	·15		22·29
15.	46·33	21·87	10·40	·95	1·29			19·16
16.	45·63	19·48	13·30	1·68	1·31	·43	·14	17·98

The average of the first and second eight analyses is as below :—

	Silica.	Alumina.	Lime.	Soda.	Potash.	Water.
1st eight	50·94	17·90	7·87	1·13	1·45	20·27
2nd eight	47·52	19·84	10·08	1·12	1·09	20·25

The table, however, indicates that the conditions under which the alterations were produced varied considerably. The analyses 1 and 2 are those of acadiolite; analyses 15 and 16 are those of phacolite from Leipa. The last is remarkable, since the lime is in excess, while the alteration has mainly occurred in the silica. The analysis 13 is that of chabasite from Faroë, and is an exception to the general statement immediately preceding the table; the lime is the only normal ingredient which has been affected, and that to a greater extent than almost any other specimen noticed in the table. Analysis 3 is that of chabasite from Parsboro' in Nova Scotia, and is a contrast to 13. These peculiarities teach little in the absence of details as to the actual conditions under which the crystals were found, and this kind of information is very scarce in the standard mineralogical manuals. In some of the more highly silicated crystals the large proportion of silica is in part due to the presence of particles of quartz, which were either entangled in the crystals when formed, or have been liberated from combination without having been removed by solution. Thus some acadiolites contain 47·94 per cent. of silica which is soluble, and 8·04 per cent. which is insoluble in carbonate of soda; while the chabasites with the smaller proportion of silica, such as that from Aussig, whose composition is represented by analysis 11, contains from 47·4 to 48·4 per cent. of soluble silica, but no quartz.

A crystal of chabasite is exceedingly sensitive to alterations in the solutions which flow by it, and, as chabasite is a good representative of the usual composition of many clay soils, we will refer to some of the changes that take place. Eichhorn made some experiments upon a chabasite having the composition represented by 1 in the subjoined table. When 4 grammes of chabasite were placed in 400 cubic centimetres of water containing 4 grammes of chloride of sodium in solution for 10 days, the change represented in analysis 2 was the result. The effect of a solution of 20 grammes of carbonate of soda in 500 cubic centimetres of water for 21 days is shown in analysis 3. The effect of a solution of 10 grammes of chloride of ammonium in 500 cubic centimetres of water for 21 days is shown in analysis 4; while that of a solution of the same strength of carbonate of ammonia for the same period is shown in the last analysis.

	Silica.	Alumina.	Lime.	Ammonia.	Potash.	Soda.	Water.
1.	47·44	20·69	10·37		·65	·42	20·18
2.	48·31	21·04	6·65		·64	5·40	18·33
3.	48·39	20·76	5·64			6·86	18·46
4.	51·26	22·17	4·15	6·94		·61	14·87
5.	50·61	21·26	5·63	5·91		·87	15·72

These experiments were performed at ordinary temperatures and prove that when surrounded by a sodium containing solution a portion of the lime is given off, while some of the soda takes its place; and when an ammoniated solution is employed the lime is replaced in part by ammonia. These artificially altered chabasites resemble none of the specimens noticed in the first table, but the second and third come nearest to analysis 13. Thus the lime only is much altered, while the silica and alumina are only slightly altered. The fourth and fifth experimental results resemble the natural crystals in the increased relative proportion of the silica, but differ in the large proportion of the alumina; in the natural specimens with more than 50 per cent. of silica there is usually a diminution in the alumina. The action of the solution is instructive as showing that the bases are only partially, not entirely replaced. Thus, with a chloride of sodium solution, a portion of the lime is replaced by soda; if such a crystal were placed in a solution of chloride of calcium it would yield up a portion of the soda only in exchange for lime; and, if placed in a solution of chloride of potassium, the potash is exchanged for portions both of the lime and soda. It is very probable that the action of solutions of varying qualities will explain the presence of the soda, potash, peroxide of iron, and magnesia observable in the recorded analyses.

Of the many specimens of chabasite none have been more instructive than those which have been found in the vicinity of certain French warm springs in association with other zeolites. At Plombières the springs which supply the baths have been built over by the Romans, and conducted along subterranean aqueducts to the place where required. The water has a temperature of 163° F., a temperature which is believed to have been nearly uniform for the last 1800 years at least. The brickwork and masonry lining the passages, and indeed, wherever the water has gained access, is permeated with zeolitic minerals, which partially fill every crevice and cranny, just as is the case with the amygdaloids, dolerites, basalts, and other rocks, which are the usual matrix for these minerals. It is noticeable that these waters flow over or through granite, gravel, &c., but the zeolites are developed only in the mortar and bricks. It would seem that the materials of the chabasite are not all brought by the springs, but that some of them are contained in the water, while the remainder occur in the mortar and bricks; and hence may be explained why the zeolites should be developed in some of the rocks and not in others. At Luxeuil the springs flow out under similar circumstances as those at Plombières, and here also the Romans have guided the waters along aqueducts constructed in the midst of solid masonry, composed of bricks, tiles, and fragments of sandstone, cemented together by a calcareous cement. All the parts accessible to the water have undergone more or less alteration. The bricks and tiles which were porous have become compact owing to the filling up of their cavities with a white substance. In this white substance may be recognised minute, but beautifully formed twin crystals of chabasite. These waters have a temperature of 115° F., or much lower than those at Plombières. It is clear, then, that chabasite does not necessitate excessively high temperatures or high pressures for its formation, and from what we have already stated it may be expected that there are many springs which will, like those just mentioned, give rise to zeolites when they permeate certain kinds of rock.

The rock which contains chabasite more frequently than any other is basalt, which is, however, generally more or less altered and porous. Chabasite is also found in trachyte, phonolites, porphyries, lavas, syenite, diorite, mica schist, gneiss, granite, and even in limestone, though very rarely.

(Dana, *A System of Mineralogy*, 5th Edition; Eichhorn in Poggendorf's *Annalen*, vol. cv., p. 126; Daubree, *Bulletin de la Société Géologique*, Second Series, tome xvi., pp. 562 *et seq.*; tome xviii., pp. 108 *et seq.*; Hunt, T. S., *American Journal of Science*, Second Series, vol. xxxix., pp. 178 *et seq.*; De la Fosse, *Nouveau Cours de Minéralogie*, tome iii., p. 312.)

CHALK FORMATION [E. C. vol. i. cols. 923—929]. The superficial distribution of the several members of the cretaceous group in England has been fully delineated in E. C., as also the cosmopolitan range of the group as a whole. Recent investigations have shown its extension into other countries than those implied in E. C. vol. i. col. 928. Not only can it be traced in what seems to have formerly been a connected continuity from near Dungiven, Londonderry County, in W. longitude 6° 55′, through England, France, Germany, Austria, Russia, Turkey, and to the borders of Asia Minor, as at Lebanon and the banks of the Dead Sea, but it extends beyond the border into the Caucasus. Following up in the same south-easterly direction we come upon other portions of the group in Eastern Bengal, Sumatra, and Borneo, or nearly as far east as 120° E. long. The most northern locality known in Europe is Thistedt in Jutland, or 57°, but in going east the northern boundary gradually trends towards the south, ranging by Grodno, Moghilev, and Simbirsk, in 54° N. lat. Nothing is known of the northern boundary of this formation east of the Ural mountains; but we may notice that the Asiatic patches carry the curve down to 25° in Bengal, and to the equator in Borneo. As illustrations of the further extension south, we may advert to the deposits of this age in Spain, Morocco, Algeria, Sicily, Greece, Egypt, and the Cape of Good Hope. The limits in America have already been roughly indicated, sufficiently so to imply that no cretaceous beds have yet been discovered in high latitudes. Although it is almost certain that the detailed examination of this group throughout its whole extent would reveal data necessitating considerable alteration in the received classifications of the subordinate members, yet for convenience sake we are compelled to use the old terms. The grouping adopted by Sir C. Lyell is thus tabulated by him:—

UPPER CRETACEOUS.

A. 1. Maestricht beds and Faxoe limestones.
2. White chalk with flints.
3. Chalk marl, or grey chalk slightly argillaceous.
4. Upper greensand, occasionally with beds of chert and with chloritic marl in the upper portion.
5. Gault, including the Blackdown beds.

LOWER CRETACEOUS (or Neocomian).

B. 1. Lower greensand—greensand, ironsand, clay, and occasional beds of limestone (Kentish Rag).
2. Wealden beds, or Weald clay and Hastings sand.

This answers very well for the British Isles, but caution is required in extending it to the beds of distant countries. It brings out the main lithological features of the group in its western extension, which is the prevalence of sands in the lower, and of calcareous beds in the upper portion, but the sands will doubtless be traced into the limestones of other areas, while the chalk will be replaced by non-calcareous deposits. The group varies from one country to another, by the interpolation or withdrawal of beds, as well as by the alteration in the lithological composition and dimensions of the strata. Judging from known facts, it seems that generally the strata are more numerous and better developed, in Europe, in passing from west to east and from north to south; so that the correct correlation of the beds of different countries is an important step towards a clear understanding of these deposits in whole or in part, whether vertically or horizontally. Our space will not admit of a full discussion of the subject, so that our best course will be to select the strata of a few limited areas upon which to make observations.

The first district we propose to dwell on is Antrim and Londonderry, as containing the most north-westerly cretaceous beds in Europe. Here, as in England, the sands prevail below, and the limestones above. Mr. Tate recognises four lithological zones. The lowest consists of dark green glauconitic and more or less argillaceous sand, or the 'glauconitic sands.' It has been traced over a distance of twenty-four miles, and found to preserve similar characters and fossils, and to be uniformly about eight feet thick. In the middle portion of this zone is a thin band of phosphatic nodules, to which the fossils are almost entirely restricted. The most important species are *Exogyra conica*, var. *lævigata*, *Pecten orbicularis*, *P. Dutemplei*, *Avicula lineata*, *Pecten quinquecostatus*, *Arca carinata*, *Belemnites ultimus*, *Ammonites varians*, *Pecten virgatus*, *Ditrupa deformis*, an assemblage which is distinguished as the zone of *Exogyra conica*. These sands pass upwards into grey marls in the easternmost part of the area, but into yellow argillaceous sandstones with chert in the westernmost part. These marls and sandstones contain fossils, which are distinguished as the zone of *Ostrea carinata*. The species, however, vary with the lithological variation of the strata; thus the yellow sandstones of Colin Glen, &c., are characterised by *Ostrea carinata*, *Pecten æquicostatus*, *P. quadricostatus*, *Rhynchonella latissima*, and *Vermicularia quinquecarinata*; while the argillaceous sandstones of Magee Island abound in *Ditrupa deformis*, *Discoidea subuculus*, *Micrabacia coronula*, and *Vermicularia quinquecarinata*. The upper surface of this zone is slightly undulated and unconformable to the beds immediately resting upon it. The third lithological zone is that termed the 'chloritic sands.' The beds consist of sands with chloritic grains and a calcareous paste. The calcareous matter is small in quantity in the lower layers increasing towards the top, and almost absent in the most western localities increasing towards the east. The species vary somewhat, according to the lithological alteration; and, if we understand aright, constitute two zoological zones. The lowermost is that of *Inoceramus Crispi*, named after the most abundant species, and characterised also by *Ostrea semiplana*, *Terebratula obesa*, *T. carnea*, *Rhynchonella robusta*, *R. latissima*, *Ostrea canaliculata*, *Pecten quinquecostatus*, *Spondylus spinosus*, *Heteropora cryptopora*, *Catopygus carinatus*, *Serpula filiformis*, *Pleurotomaria perspectiva*, *Cidaris vesiculosa*, and *Epiaster distinctus*. This zone prevails in the lower and more sandy portions of the chloritic sands, but is best developed in the west of Antrim. The second zoological zone is that of *Exogyra columba*, this species being associated with *Cucullæa fibrosa*, *Trigonia dædalea*, *Pecten æquicostatus*, *Waldheimia hibernica*, *Ostrea semiplana*, *Ammonites lewesiensis*, *Corax falcatus*, *Otodus appendiculatus*, *Ptychodus mammillaris*, *Anatina royana*, *Cardium gibbosum*, *Inoceramus striatus*. The maximum thickness of the chloritic sand is fifteen feet six inches. The fourth lithological zone is the "white limestone with flints," which is divisible into three, if not four, zoological horizons. The lowest beds consist of a chloritic limestone, which, however, first passes into a chloritic sandstone, and then thins out towards the west. Where thinnest it is represented by a band, two or three inches thick, of *Ananchytes gibbus*, associated with a few *Ventriculites*. The sponges, however, belong to a distinct zone from the echinids termed the 'spongarian,' as is shown where these beds are more fully developed; the characteristic species of which zone are *Camerospongia fungiformis*, *Ventriculites alternans*, *V. decurrens*, and *Etheridgia mirabilis*. Still higher comes the 'white limestone,' which is an imperfectly bedded compact white lime stone, much altered in structure, and with numerous bands of shattered flints. This limestone varies in thickness, from about 100 feet at Whitehead to a few feet in Colin Glen. The variation in thickness is partly due to denudation, which has evidently been considerable, since the upper surface is eroded, worn into holes, and covered with a layer of gravel, composed of chalk flints in an ochreous clay. This gravel, together with the overlying bituminous band and sheets of basalt, belong to a post-cretaceous period. The species characteristic of the limestone are *Ammonites gollevillensis*, *Belemnitella mucronata*, *Turritella unicarinata*, *Cinulia catenata*, *Ostrea vesicularis*, *Pholadomya cordata*, *P. Stewarti*, *Pecten nitidus*, *Terebratula carnea*, *Rhynchonella octoplicata*, *Megerlia lima*, *Ananchytes ovatus*, type and var. *pyramidatus*, *Cardiaster ananchytis*, *Galerites abbreviatus*, *Cyphosoma corollare*, *Parasmilia centralis*, *Guettardia stellata*, *Paramoudra Bucklandi*.

The conclusions to which these facts lead Mr. Tate are, that—"(1) The cretaceous rocks of Ireland are referable to two formations, the Hibernian greensand and the upper chalk. (2) The Hibernian greensand is divisible into well-marked lithological and palæontological zones, and is the equivalent in miniature of the Étage Cénomanien of D'Orbigny. (3) The zone of *Exogyra conica* represents the basement beds of the Étage Cénomanien of the French geologists, and is approximately equivalent to the greensand of Blackdown. (4) The zone of *Ostrea carinata* represents most certainly a portion of the upper greensand of England and the lower Cénomanien of Nomandy. (5) The chloritic sands and sandstones have, on the whole, a fauna possessing an upper greensand facies, many species, however, pointing to higher zones. It is very probable that the chloritic sands of Woodburn (the 'zone of *Inoceramus Crispi*' (?)) may be inferior to the chloritic sandstones of Colin Glen, the 'zone of *Exogyra columba*.' These two zones, however, never come into contact. (6) The upper chalk contains three subdivisions:—(*a*) Zone of *Ananchytes gibbus*; (*b*) Spongarian zone; (*c*) White limestone, or the zone of *Ammonites gollevillensis*. The white limestone certainly represents the upper chalk of Norwich and the 'craie de Meudon,' and some of its fossils point even to a higher parallel, that of the Maestricht chalk."

As it will facilitate comparison with the beds of other countries, we append the following table, which represents a list of all the Irish cretaceous fossils known in 1864. It is the same as that given by Mr. Tate, but somewhat differently arranged. The simple occurrence of the species is indicated by a star; v. c. means that it is very common; c. that it is common; r. rare; and v. r. very rare.

	Glauconitic Sands.	Yellow Sands and Marls.	Chloritic Sandstone.	Chloritic Chalk.	White Limestone.
Protozoa.					
Rhizopoda.					
Orbitolina concava	—	—	*		
Spongidæ.					
Brachiolites protensus	—	*			
Ventriculites decurrens	—	—	—	*	
V. tessellatus	—	—	—	*	
V. Murchisoni	—	—	—	*	
Cephalites Bennettiæ	—	—	—	*	
Camerospongia fungiformis	—	—	—	v. c.	
Etheridgia mirabilis	—	—	—	c.	
Coscinopora infundibuliformis	—	—	—	*	
Cœloptychium furcatum	—	—	—	*	
Cœloscyphia sulcata	—	—	—	*	
Hippalimus	—	—	—	*	
Amorphospongia perreticulatum	—	—	—	*	
Ventriculites alternans	—	—	—	*	*
V. radiatus	—	—	—	*	*
Amorphospongia globularis	—	—	—	v. c.	c.
Cliona cretacea	—	—	—	*	*
Guettardia stellata	—	—	—	—	c.
Cœloptychium belfastiense	—	—	—	—	*
Cœloscyphia paramoudra	—	—	—	—	*
Siphonia sp.	—	—	—	—	*
S. cervicornis	—	—	—	—	*
Amorphospongia ramosa	—	—	—	—	*
Talpina dendrina	—	—	—	—	*
Cœlenterata.					
Actinozoa.					
Micrabacia coronula	—	*			
Stelloria sulcata	—	—	*		
Synastrea superposita	—	—	*		
Cœlosmilia laxa	—	—	—	—	r.
Cyathina lævigata	—	—	—	—	r.
Parasmilia centralis	—	—	—	—	*
Hydrozoa. None.					
Annulosa.					
Echinodermata.					
Discoidea subuculus	—	*			
Epiaster distinctus	—	*	*		
Cidaris vesiculosa	—	—	*		
C. Sorigneti	—	—	*		
Cyphosoma cenomanense	—	—	*		
Echinoconus subrotundus	—	—	*		
Discoidea cylindrica ?	—	—	*		
Epiaster crassissimus	—	—	*		
Catopygus columbarius	—	—	c.		
Goniaster sp.	—	—	*		
Bourgueticrinus ellipticus	—	—	* ?	—	*
Echinoconus conicus, var tumidior	—	—	—	*	
Echinocorys gibbus	—	—	—	*	
Echinoconus conicus (type)	—	—	—	*	*
Echinocorys vulgaris (type)	—	—	—	*	*
Cidaris sp.	—	—	—	—	*
Cyphosoma corollare	—	—	—	—	*
Echinoconus abbreviatus	—	—	—	—	*
Cardiaster ananchytis	—	—	—	—	*
Micraster cor anguinum	—	—	—	—	*
Holaster pilula	—	—	—	—	*
H. Sandoz	—	—	—	—	*
Echinocorys sulcatus	—	—	—	—	v. r.
E. vulgaris, var. pyramidata.	—	—	—	—	*
Salenia Portlocki	—	—	—	—	*
Annelida.					
Serpula antiquata	*				
Vermicularia quinquecarinata	*	v. c.			
Ditrupa deformis	*	v. c.	*		
Vermilia ampullacea	—	*	*		
Vermicularia concava	—	—	v. c.		
Serpula filiformis	—	—	v. c.		
S. plexus	—	—	*		
S. lævis	—	—	*		
S. vibicata ?	—	—	*		
Ditrupa cretacea	—	—	—	—	*
Serpula planus	—	—	—	—	*
Crustacea.					
Scalpellum trilineatum ?	—	*			
Pollicipes glaber	—	*			
Callianassa sp.	—	—	c.		
Loricula McAdami	—	—	*		
Scalpellum maximum	—	—	—	—	*
Mollusca.					
Polyzoa.					
Desmeopora cylindrica	—	—	*		
D. aculeata	—	—	*		
Retepora clathrata	—	—	*		
Pustulipora pustulosa	—	—	*		
Proboscina ramosa	—	—	*		
Diastopora oceani	—	—	*		
D. tubulosa	—	—	*		
Zonopora variabilis	—	—	*		
Heteropora cryptopora	—	—	*	*	*
Retepora ramosa	—	—	—	*	
Semieschara Normaniana	—	—	—	*	
Holostoma contingens	—	—	—	—	*
Membranipora parisiensis	—	—	—	—	*
Brachiopoda.					
Terebratula squamosa	*				
Rhynchonella plicatilis	*				
R. latissima	—	*			
R. l. var.	—	—	v. c.		
R. limbata var. robusta	—	—	v. c.		
Terebratula biplicata	—	—	*		
Waldheimia hibernica	—	—	*		
Terebratulina striata	—	—	*	—	*
Terebratula carnea	—	—	v. c.	—	v. c.
T. obesa	—	—	v. c.	—	r.
Crania Ignaburgensis	—	—	—	—	*
Terebratulina Defrancea	—	—	—	—	*
Terebratula semiglobosa	—	—	—	—	*
T. abrupta	—	—	—	—	*
Megerlia lima	—	—	—	—	*
Rhynchonella limbata, var. lentiformis	—	—	—	—	*
R. plicatilis	—	—	—	—	v. c
R. octoplicata	—	—	—	—	v. c.
Lamellibranchiata.					
Exogyra conica var. lævigata	v. c.				
Pecten glauconeus	*				
P. sp.	*				
P. cometa	*				
P. virgatus	*				
Plicatula deltoidea	*				
Avicula sublineata	v. c.				
Cucullæa carinata	*				
C. two sp.	*				
Lucina orbicularis	*				
Venus caperata ?	*				
Thetis major	*				
Myacites læviuscula	*				
M. mandibula	*				
Trigonia sp.	*				
Ostrea carinata	v. r.	c.			
Exogyra conica, var. plicata	*	*			
E. haliotoidea	*	*			
Pecten orbicularis	v. c.	v. r.			
P. asper	*	*	*		
P. Dutemplei	v. c.	v. r.	v. r.		
P. quinquecostatus	c.	*	v. c.		
P. æquicostatus	* ?	*	*		
Ostrea canaliculata	*	—	v. c.		
Pecten quadricostatus	—	r.	r.	—	*
Ostrea sp.	—	—	v. r		
O. semiplana	—	—	v. c.		
Exogyra columba	—	—	c.		
E. laciniata	—	—	v. r.		
Lima semiornata	—	—	*		
L. simplex	—	—	*		
Spondylus striatus	—	—	*		
Inoceramus Crispi	—	—	v. c.		
I. striatus	—	—	*		
Pinna subtetragona	—	—	*		
Mytilus subfalcatus	—	—	*		
Cucullæa ligeriensis	—	—	*		
Arca sp.	—	—	*		
Cardium gibbosum	—	—	*		
Cardita dubia	—	—	*		
Cytheræa, 2 sp.	—	—	*		
Cercomya royana	—	—	*		
Trigonia crenulata	—	—	*		
T. dædalea	—	—	*		
Trigonia, 2 sp.	—	—	*		
Spondylus spinosus	—	—	v. c.	—	*
Venus subparva	—	—	—	c.	
Ostrea vesicularis	—	—	—	—	v. c.
Pecten sexcostatus	—	—	—	—	* ?

	Glauconitic Sands.	Yellow Sands and Marls.	Chloritic Sandstone.	Chloritic Chalk.	White Limestone.
Pecten nitidus	—	—	—	—	*
Lima elegans	—	—	—	—	*
L. Hoperi	—	—	—	—	*
L. semisulcata	—	—	—	—	*
Arca albacretæ	—	—	—	—	*
Chama inæquirostrata	—	—	—	—	*
Astarte lenticularis	—	—	—	—	*
Isocardia cretacea	—	—	—	—	*
Cypricardia trapezoidalis	—	—	—	—	*
Pholadomya cordata	—	—	—	—	*
P. obliquissima	—	—	—	—	*
P. Stewarti	—	—	—	—	*
Gervillia angusta	—	—	—	—	*
Gasteropoda.					
Littorina subrotunda	*				
Solarium ornatum (?)	*				
Pleurotomaria Mailleana	—	—	*		
P. perspectiva	—	—	*		
Cinulia avellana	—	—	*		
Fusus royanus	—	—	—	—	*
Rostellaria sp.	—	—	—	—	*
Turritella unicarinata	—	—	—	—	v. c.
Scalaria albacretæ	—	—	—	—	*
Trochus cirrus	—	—	—	—	v. c
T. Basteroti	—	—	—	—	c.
T. sp.	—	—	—	—	*
T. regalis	—	—	—	—	*
Turbo Zekeli	—	—	—	—	r.
Pleurotomaria Thomsoni	—	—	—	—	*
P. disticha (?)	—	—	—	—	*
P. sp.	—	—	—	—	*
Calyptræa Grayana	—	—	—	—	*
Patella orbis	—	—	—	—	*
Cinulia catenata	—	—	—	—	*
Emarginula cancellata	—	—	—	—	*
Pyrula rapulum	—	—	—	—	*
Dentalium planicostatum	—	—	—	—	*
Heteropoda. None.					
Pteropoda. None.					
Cephalopoda.					
Ammonites varians	*				
Belemnites ultimus	*				
Ammonites lewesiensis	—	—	*		
Nautilus Deslongchampsianus	—	—	*		
Belemnitella mucronata	—	—	—	*	v. c.
Ammonites gollevellensis	—	—	—	—	v. c.
A. occlusus	—	—	—	—	*
A. Portlocki	—	—	—	—	*
A. Jukesi	—	—	—	—	*
A. Griffithsi	—	—	—	—	*
A. Oldhami	—	—	—	—	*
Scaphites elegans	—	—	—	—	*
Helicoceras hibernicum	—	—	—	—	*
Hamites Carolinus	—	—	—	—	*
Nautilus lævigatus	—	—	—	—	c.
N. radiatus	—	—	—	—	*
Baculites anceps	—	—	—	—	*
B. Faujasi	—	—	—	—	*
B. obliquatus	—	—	—	—	*
Vertebrata.					
Pisces.					
Otodus appendiculatus	* ?	—	*	—	*
Lamna acuminata	—	—	*		
Gyrodus cretaceus	—	—	c.		
Ptychodus mamillaris	—	—	*		
P. polygyrus	—	—	*		
Corax falcatus	—	—	*	—	v. r
Notidanus microdon	—	—	—	—	*
Beryx sp.	—	—	—	—	*
Oxyrhina Mantelli	—	—	—	—	*
Reptilia.					
Plesiosaurus	*				
Aves. None.					
Mammalia. None.					

Nearly in the same latitude as the Irish beds, but about 6° farther east, we meet with the most northern of the English deposits of this age. The range of hills forming the Yorkshire wolds projects seaward, as Flamborough Head; north of this projection is a bay, which finds its counterpart depression in a long inland valley; the north side of the bay is bounded by Filey Point, which is the continuation of a range of hills of less elevation than, but nearly parallel to, that of the Yorkshire wolds. This configuration of the coast and country is correlated with the nature of the deposits. The high hills and the bold cliff range of Flamborough are moulded out of hard chalk; the depression consists of the Speeton clays; while the horizontal and vertical prominences which bound these on the north, mark the site of the hard coral rag. Topographically, the Speeton clays intervene between deposits of middle oolitic and upper cretaceous ages, and considering the general arrangement of the English strata east and south of the water-shed, it might be expected that the Speeton clays would be intermediate in age between the coral rag and white chalk. This is the case, as will be shown presently. The Speeton clays were once assigned wholly to the Kimmeridge clay, but Phillips first directed attention to the widely distinct ages of the upper and lower portions, assigning the latter to the Kimmeridge clay, and the former to the Gault. Agassiz, Römer, Godwin-Austen, Forbes, Fitton, and D'Orbigny paralleled them with the Neocomian beds of the continent. Leckenby recognised the upper portion only as of Neocomian age, an opinion which has recently been supported by Judd, who further correlates the lower portion with the uppermost marine beds of the oolitic series. This conclusion is especially noteworthy, for if true, it indicates that the Portland sands and stones of the south of England are represented by the Speeton clays (in part) of Yorkshire, and that in this district clays only were deposited in the interval between the coral rag and the chalk. The uniformity of lithological composition had misled previous observers into supposing that the beds were deposited in continuous succession; but careful research has shown that the lower portion is separated from the upper by a well-marked palæontological break, which is associated with a layer of phosphatic nodules. This layer is considered by Messrs. Leckenby and Judd to mark the junction of the Neocomian and oolitic beds. Disregarding the lower beds, and taking this as a datum line, we will indicate the succession of the cretaceous strata from below upwards. At the base there is from 50 to 100 feet of a dark-coloured shaley clay, so highly impregnated with iron-pyrites, that the exposed surfaces are usually covered with a yellowish-white efflorescence of sulphate of iron. This forms the zone of *Ammonites asterianus*, the organic contents of which will be seen from the subjoined table. Above this comes about 50 feet of dark blue clays, forming the zone of *Ammonites noricus*. This is followed by about 100 feet of similar clays, or the zone of *Ammonites speetonensis*. The three zones above mentioned are grouped together as the 'Lower Neocomian.' The 'Middle Neocomian' consists of about 150 feet of dark blue clays. At the base is a band containing numerous septaria, which is designated the 'Ancyloceras bed.' Higher up are several layers of dark brown nodules, many of which contain some organic fragment as a nucleus. Thus, in one seam almost every nodule contains a more or less perfect specimen of *Meyeria ornata*. Towards the summit the septaria become far less abundant. This division is probably equivalent to the Tealby series, and possibly also to the beds above and below them. The lithological change is considerable. The lowermost 30 or 40 feet, in Lincolnshire, is an arenaceous mass which varies from sand to compact sandstone, of numerous shades of colour, from white to dark brown. The thickness of the sands and sandstones increases towards the south. The Tealby series consists of alternations of sandy clays and sandy limestones, and have a thickness of from 40 to 50 feet. This is capped by about 20 feet of non fossiliferous ferruginous sands. The upper Neocomian beds of Speeton commence with a light blue clay, abounding in large septaria composed of argillaceous limestone, and crowded with fossils. It is locally well known as the 'Cement bed.' Above it are dark blue clays, about 50 feet thick, which contain a few scattered septaria, and a few fossils. The highest beds are black clays, with beautifully crystallised nodules of iron-pyrites, but almost destitute of organic remains. Above this follow—(1) the Hunstanton limestone; (2) chalk, with coloured bands; and (3) white chalk. This series dips at a much slighter angle than the Neocomian, so that the Hunstanton limestone is decidedly unconformable to the underlying strata. This unconformability is also displayed further south in Lincolnshire, and is brought forward by Mr. Judd as antagonistic to the view that any part of the Speeton clays can be assigned to the Gault, inasmuch as this seems to be represented by the Hunstanton limestone. This limestone decreases in thickness in its southern extension, and has been traced, more or less continuously, from Yorkshire to the cliffs at Hunstanton, where it forms a conspicuous feature. At the last mentioned locality the lowest bed exposed is a clay surmounted by a layer of nodules, from which have been obtained the species in the column of the subjoined table, headed 'Hunstanton carstone.' Above it succeeds a coarse sandy deposit full of small subangular and polished pebbles, well known in the district as the 'carstone.' Its thickness is above 30 feet. The 'red chalk' overlies this, and presents peculiarities which have thus been described by the Rev. P. Wiltshire. The lowest portion of the overlying chalk is indicated by *b.*, and the underlying 'carstone' by X, Y. "Lithologically, it is unlike the beds above it, from the fact of its abounding in great numbers of rolled and subangular pebbles of quartz, slate, &c., which, for the most part, are of small size, and insignificant, though occasionally assuming large dimensions. In appearance it is divisible into three almost equal portions, of which the first (A) has, towards its base, a large quantity of fragments of *Inocerami*, the second and thickest division (B) is rich in *Belemnites*, and the third and lowest (C) yields many *Terebratulæ*. The bands A and B are exceedingly hard and stony, and sufficiently tabular in character to have offered a plane of resistance to former upheaving forces, and to have afforded great support to the overlying white beds; thus, although the whole cliff was evidently, in ancient geological times, much disturbed, the perpendicular fissures which rise out of the yellow bands (X, Y), just before reaching the layer B, affect the red beds to the right and left of the points of application, and then start upwards through the white stratum in new positions, and in greater number. The colouring matter in A is less equally distributed than in B and C, and seems to have been accumulated around irregular masses; in B the tint is of a lighter shade, and in C of a darker shade than in the highest division. The middle bed (B) is in substance the hardest and most homogeneous of the three; the last (C) is the least compact. Viewed in the cliff, it wears a mottled aspect, B a nodular facies, and C a plane surface. Towards the base of the bottom bed C, the hard limestone character of the red chalk is lost, and the stratum degenerates into a somewhat sandy incoherent mass, hardly differing from the underlying yellow division, except in colour. On account of the less compact nature of the last of the three beds, fossils are more easily procured from it, have their surfaces in better condition, and are more readily seen when of small size. Resting on the top of A, and filling the undulations on the underside of the lowest white bed (*b*), is a bright red argillaceous substance, very friable, without sand, apparently destitute of organic remains, and never exceeding two or three inches. The fossils in the three red beds are for the most part similar, and suggest the inference that all three bands may be considered as forming a single division, and composing one geological stratum. In the case where certain fossils have been seen only in the lowest part, their absence elsewhere may be accounted for on the ground that the upper bed (A) is less numerically abundant in organic remains than are those below, and that the middle bed (B) is so exceedingly hard and compact as to diminish the chance of discovering fossils. *Avicula gryphæoides* and *Spongia paradoxica*, would seem, however, to be special to the upper part of it, the highest of the three red beds. The dip of these beds in the cliff is about 2° to the north; sections inland taken at right angles give the same number of degrees to the east." The fossils of this remarkable stratum are entered in the subsequent table under the heading of Hunstanton Red Chalk. This table is based upon those given in the under cited papers by Judd and Wiltshire. We have altered the arrangements so as to facilitate the comparison of the faunas of the various beds with each other, as well as with those of the Irish deposits already given; but we retain the names as given by each author:—

	Lower Neocomian. (Speeton.)			Middle Neocomian.		Upper Neocomian.	Hunstanton.	
	Zone of Am. Asterianus.	Zone of Am. Noricus.	Zone of Am. Speetonensis.	Speeton.	Tealby Series.	Speeton.	Carstone.	Red Chalk.
Protozoa.								
Spongidæ.								
Spongia paradoxica	—	—	—	—	*	—	—	c.
Scyphia clavellata	—	—	—	—	*			
S. tenuis	—	—	—	—	—	—	—	r.
Cœlenterata.								
Actinozoa.								
Trochocyathus conulus	—	—	—	—	—	r.		
Micrabacia coronula	—	—	—	—	—	—	—	c.
Cyclolites polymorpha	—	—	—	—	—	—	—	c.
Podoseris mamilliformis	—	—	—	—	—	—	—	c.
P. elongata	—	—	—	—	—	—	—	r.
Annulosa.								
Echinodermata.								
Toxaster complanatus	v. r.	—	—	—	—	* ?		
Pentacrinus sp.	—	—	r.					
P. sp.	—	—	—	r.	—	r.		
P. angulatus	—	—	—	r.	—	c.		
Cidaris sp.	—	—	—	—	*			
C. gaultina	—	—	—	—	—	—	—	r.
C. sp.	—	—	—	—	—	—	—	v. r.
Pseudodiadema Brongniarti	—	—	—	—	—	—	—	r.
P. ornatum	—	—	—	—	—	—	—	r
Salenia Wiltshirei	—	—	—	—	—	—	—	r.
Holaster suborbicularis	—	—	—	—	—	—	—	c.
Bourguetocrinus rugosus	—	—	—	—	—	—	—	c.
Torynocrinus canon	—	—	—	—	—	—	—	c
Pentacrinus Fittoni	—	—	—	—	—	—	—	c.
Annelida.								
Serpula articulata	—	—	r.	—	—	c.		
S. gastrochænoides	—	—	—	r.				
S. filiformis	—	—	—	c.	*	c.		
S. antiquata	—	—	—	c.	*	r.	—	r.
Vermicularia Phillipsii	—	—	—	r.	—	v. c.		
V. Sowerbii	—	—	—	—	r.			
Serpula sp.	—	—	—	—	*			
S. cristata	—	—	—	—	—	—	—	r.
S. depressa	—	—	—	—	—	—	—	r.
S. rustica	—	—	—	—	—	—	—	r.
Vermicularia umbonata	—	—	—	—	—	—	—	c.
Crustacea.								
Astacodes falcifer	—	—	r.					
Meyeria ornata	—	—	—	v. c.				
M. vectensis	—	—	—	—	—	?		
Pollicipes unguis	—	—	—	—	—	—	—	v. r.
Mollusca.								
Polyzoa.								
Berenicea regularis	—	—	—	—	—	—	—	c.
Reptomulticava mamilla	—	—	—	—	—	—	—	c.
Proboscina dilatata	—	—	—	—	—	—	—	r.
Stomatopora longiscuta	—	—	—	—	—	—	—	r.
Brachiopoda.								
Terebratula depressa. (?)	—	—	r.	r.	*	r.		
Rhynchonella sulcata	—	—	r.	r.	—	r.		
Waldheimia celtica	—	—	—	r.				
Terebratula sella	—	—	—	r.	*	c.		
T. hippopus	—	—	—	?	*	—		
T. faba	—	—	—	—	*			
T. biplicata	—	—	—	—	*	—	*	v. c.
Rhynchonella parvirostris	—	—	—	—	*			
R. gibbsiana	—	—	—	—	*			
Terebratulina striata, var. pentagonalis	—	—	—	—	—	v. r.		
Rhynchonella lineolata	—	—	—	—	—	v. r.		
R. sp.	—	—	—	—	—	v. r.		
Discina sp.	—	—	—	—	—	v. r.		
Lingula truncata	—	—	—	—	—	r.		
Terebratula capillata	—	—	—	—	—	—	—	c.
T. semiglobosa	—	—	—	—	—	—	—	r.
Terebratulina gracilis	—	—	—	—	—	—	—	r.
Kingena lima	—	—	—	—	—	—	—	r.
Lamellibranchiata.								
Exogyra Couloni	v. c.							
E. C. var. dorsata	v. c.							
E. C. var. falciformis	v. c.							
E. C. var. aquilina	r.							
Teredo sp.	r.	—	r.					
Ostrea sp.	—	r.	r.					
Pholas constricta	—	r.	r.					
Astarte laticosta	—	?	r.	r.	—	r.		
Thracia Phillipsia	—	r.	c.	c.	—	v. c.		
Pholadomya sp.	—	—	r.					
Exogyra subplicata	—	—	c.					
Pecten cinctus	—	—	v. r.	v. c.	*	r.		
Exogyra sinuata	—	—	r.	v. c.	*	c.		
Nucula subrecurva	—	—	r.	—	—	c.		
N. obtusa	—	—	r.	r.	—	v. c.		
Lucina sculpta	—	—	—	v. r.				
Lima sp.	—	—	—	r.				
Exogyra sinuata var. elongata	—	—	—	c.				
Lucina crassa	—	—	—	r.	*			
Ostrea frons	—	—	—	r.	*	r.		
Pholadomya sp.	—	—	—	r.	—	r.		
P. Martini	—	—	—	c.	—	c.		
P. neocomiensis	—	—	—	c.	—	v. c.		
Panopæa plicata	—	—	—	?	*	c.	*	
Ostrea sp.	—	—	—	—	*			

	Lower Neocomian. (Speeton.)			Middle Neocomian.		Upper Neocomian.	Hunstanton.	
	Zone of Am. Asterianus.	Zone of Am. Noricus.	Zone of Am. Speetonensis.	Speeton.	Tealby Series.	Speeton.	Carstone.	Red Chalk.
Anomia sp.	—	—	—	—	*			
Perna Ricordeana (?)	—	—	—	—	*			
Lima sp.	—	—	—	—	*			
Astarte substriata	—	—	—	—	*			
Pleuromya sp.	—	—	—	—	*			
Thetis Sowerbii	—	—	—	—	*			
Trigonia alæformis	—	—	—	—	*			
Pecten elongatus	—	—	—	—	*	c.		
P. orbicularis	—	—	—	—	*	v. c	*	
Ostrea Leymerei	—	—	—	—	—	v. r.		
Pecten interstriatus	—	—	—	—	—	v. r.		
Exogyra parvula	—	—	—	—	—	r.		
E. sp.	—	—	—	—	—	r.		
Lima undata	—	—	—	—	—	r.		
L. elegans	—	—	—	—	—	r.		
Plicatula placunea	—	—	—	—	—	r.		
Gervillia anceps (?)	—	—	—	—	—	r.		
Inoceramus concentricus (?) (small var.)	—	—	—	—	—	r.		
I. imbricatus	—	—	—	—	—	r.		
Pinna gracilis	—	—	—	—	—	r.		
Cucullæa securis, var. major	—	—	—	—	—	r.		
Corbis sp.	—	—	—	—	—	r.		
Astarte lævis	—	—	—	—	—	r.		
Isocardia sp.	—	—	—	—	—	r.		
Trigonia spinosa	—	—	—	—	—	?		
Thetis Sowerbii, var. major	—	—	—	—	—	r.		
T. S., var. minor	—	—	—	—	—	c.		
Lima (2 species)	—	—	—	—	—	c.		
Avicula sp.	—	—	—	—	—	c.		
Inoceramus venustulus	—	—	—	—	—	c.		
Mya (?) phraseolina	—	—	—	—	—	c.		
Pholadomya sp.	—	—	—	—	—	c.		
Pecten striato-punctatus	—	—	—	—	—	v. r.	*	
Perna Mulleti	—	—	—	—	—	c.	*	
Nucula obtusa, var. planata	—	—	—	—	—	v. c.	*	
Isocardia angulata	—	—	—	—	—	v. c.	*	
Trigonia sp.	—	—	—	—	—	—	*	
Leda sp.	—	—	—	—	—	—	*	
Avicula macroptera	—	—	—	—	—	—	*	
Cardium subhillanum	—	—	—	—	—	—	*	
Lima Iteriana	—	—	—	—	—	—	—	v. r.
Exogyra conica	—	—	—	—	—	—	—	r.
E. haliotoidea	—	—	—	—	—	—	—	r.
E. laciniata	—	—	—	—	—	—	—	r.
E. Rauliniana	—	—	—	—	—	—	—	r.
Inoceramus sulcatus	—	—	—	—	—	—	—	r.
I. subsulcatus	—	—	—	—	—	—	—	r.
Lima globosa	—	—	—	—	—	—	—	r.
Pecten Beaveri	—	—	—	—	—	—	—	r.
Plicatula pectinoides	—	—	—	—	—	—	—	r.
Avicula gryphæoides	—	—	—	—	—	—	—	c.
Inoceramus Crispi	—	—	—	—	—	—	—	c.
I. tenuis	—	—	—	—	—	—	—	c.
Ostrea Normaniana	—	—	—	—	—	—	—	c.
O. vesicularis	—	—	—	—	—	—	—	c.
Spondylus striatus	—	—	—	—	—	—	—	c.
Gasteropoda.								
Dentalium lævigatum	—	—	r.					
Trochus sp.	—	—	r.					
Cerithium aculeatum	—	—	r.					
C. Phillipsii (?)	—	—	—	r.				
C. sp.	—	—	—	r.				
Trochus sp.	—	—	—	r.				
Pleurotomaria sp.	—	—	—	—	*			
Solarium ornatum (?)	—	—	—	—	*			
Emarginula neocomiensis	—	—	—	—	—	v. r.		
Cerithium Clementinum, var.	—	—	—	—	—	r.		
Turritella lævigata	—	—	—	—	—	r.		
Solarium tabulatum	—	—	—	—	—	r.		
Delphinula (?) sp.	—	—	—	—	—	r.		
Dentalium ellipticum (?)	—	—	—	—	—	r.		
Auricula obsoleta	—	—	—	—	—	c.		
Trochus (?) pulcherrimus	—	—	—	—	—	c.		
T. granulatus	—	—	—	—	—	v. c.		
Rostellaria Parkinsoni	—	—	—	—	—	v. c.		
R. bicarinata	—	—	—	—	—	v. c.		
Dentalium sp.	—	—	—	—	—	—	*	
Pleurotomaria gigantea	—	—	—	—	—	—	*	
P. sp.	—	—	—	—	—	—	—	r.
Cerithium mosense	—	—	—	—	—	—	—	r.
Cephalopoda.								
Ammonites multiplicatus, var. ? hystrix	v. r.							
A. multiplicatus	r.							
A. Asterianus	r.	v.r.?						
Belemnites lateralis	v. c.	c.	r.	—	*			
Ammonites Noricus	—	c.						
A. N., var. furcillatus	—	c.						
A. raricostatus	—	c.						
Ancyloceras Emericii	—	r.	c.	v. c.				
A. Duvalii	—	r.	c.	v. c.	*			
A. Puzosianum	—	c.	r.	—	*			
Ammonites rotula	—	r.	c.	c.	—	r.		
A. marginatus	—	c.	c.	c.	—	c.		
A. trisulcosus	—	—	r.					
A. sp.	—	—	r.					
A. speetonensis, var. venustus	—	—	v. c.					
A. s., var. concinnus	—	—	v. c.					
Belemnites jaculus	—	—	r.	v. c.	*			
Ammonites Nisus	—	—	r.	r.	—	c.		
A. nucleus	—	—	r.	r.	—	c.		
A. cryptoceras	—	—	—	v. r.				
A. angulicostatus	—	—	—	v. r.				
A. crassicostatus	—	—	—	v. r.				
Ancyloceras sp.	—	—	—	r.				
Belemnites sp.	—	—	—	r.				
B. semicanaliculatus	—	—	—	v. r.	*	v. c.		
Ammonites clypeiformis	—	—	—	—	*			
A. plicomphalus	—	—	—	—	*			
Crioceras (?) Bowerbankii	—	—	—	—	*			
Belemnites minimus (?)	—	—	—	—	*	?	—	v. c.
Ammonites (2 species)	—	—	—	—	—	v. r.		
A. Deshayesii, var. curvinodus	—	—	—	—	—	v. r.		
A. bipinnatus	—	—	—	—	—	c.		
Ancyloceras grande	—	—	—	—	—	c.		
A. sp.	—	—	—	—	—	c.		
A. sp.	—	—	—	—	—	v. c.		
Ammonites Deshayesii	—	—	—	—	—	v. c.	*	
Belemnites ultimus	—	—	—	—	—	?	—	v. c.
Ammonites Cornuelianus	—	—	—	—	—	—	*	
Ancyloceras gigas	—	—	—	—	—	—	*	
Nautilus albensis	—	—	—	—	—	—	—	r.
N. Bouchardianus	—	—	—	—	—	—	—	r.
Ammonites Beudanti	—	—	—	—	—	—	—	r.
A. rostratus	—	—	—	—	—	—	—	r.
A. auritus	—	—	—	—	—	—	—	c.
A. lautus	—	—	—	—	—	—	—	c.
Belemnites attenuatus	—	—	—	—	—	—	—	v. c.
Vertebrata.								
Pisces.								
Vertebræ and other remains	r.	r.	c.	r.	—	c.		
Lamna sp.	—	—	r.	—	—	c.		
Ischiodon sp.	—	—	—	—	—	—	—	r.
Otodus appendiculatus	—	—	—	—	—	—	—	v. c.
Reptilia.								
Ichthyosaurus sp.	—	—	—	—	*			
Plesiosaurus sp.	—	—	—	—	*	r.		
Teleosaurus sp.	—	—	—	—	—	v. r.		
Plesiosaurus latispinus (?)	—	—	—	—	—	—	—	*

We shall offer no remarks upon this table beyond referring to the marked dissimilarity of the fauna of the red chalk from those of the older strata, there being only 5 out of 60 species in common. The table is full, but by no means complete, and is intended to indicate roughly what is known of the distribution of the species in the lower cretaceous beds of the east of England.

The 'Carstone' is believed to be the representative of the lower greensand, as developed in the south of England—a stratum which is remarkable for its varied alterations in lithological character, in passing from district to district. Although almost unfossiliferous at Hunstanton, it abounds in organic remains in places further southwards. At Ely it is known as the Shanklin sands, and consists of a conglomerate of small rounded pebbles in the lower portion, and of brown sands alternating with layers of clay, with phosphatic nodules in the upper. At Upware and Potton it also consists of sands, alternating with beds containing phosphatic nodules; but at these localities numerous fossils, chiefly brachiopoda, have been collected. The discovery of fossils is much facilitated by the extensive diggings which are made for the nodules at the places named, as also at and near Sandy in Bedfordshire. Near Hartwell in Buckinghamshire these sands still possess a coarse, highly ferruginous, pebbly character; the pebbles are frequently large, more or less rounded, and consist of various substances, such as quartz, quartzite, Lydian stone, &c. No phosphatic nodules have been noticed, but there are casts of the shells of several species of molluscs, such as *Lima undata, Pecten distriatus, P. Cottaldinus* (?), *Exogyra sinuata, Rhynchonella antidichotoma, Pholas cornuelliana*, &c. The cretaceous beds beneath the gault of the southern counties of England expand in thickness from west to east, and from north to south; in these directions also they pass from a prevalent arenaceous character to beds of a more varied description, owing to the accession of clays, and in places calcareous matter. The increase in thickness from about 40 feet near Lyme Regis, to upwards of 400 feet at Folkestone, does not arise so much from the interpolation of fresh beds as from the appearance of lower and distinct strata. The beds at Lyme Regis are probably the representatives of the green sand at Blackdown and Warminster, the sponge gravels at Farringdon, the pebble beds and carstone at Godalming, and the Folkestone beds at Folkestone, where the thickness is 70 feet. At Folkestone the lowest beds consist of the Atherfield clay, which has been traced west as far as Guildford and Atherfield, preserving nearly the same thickness and composition everywhere. The Hythe beds consist of compact limestone and sandstone in the east, but towards the west, as at Guildford, Godalming, and the Isle of Wight, it is almost a sand. Above these, and immediately beneath the Folkestone beds, are the Sandgate beds, which form a mass of dark coloured argillaceous sands, which lose a large portion of the clayey ingredient towards the west. These lower greensand strata are best displayed in England in their most southern locality, viz., the Isle of Wight; and we incorporate the following descriptions and lists of fossils, from the 'Memoir of the Geological Survey' on the Isle of Wight, for comparison with the Yorkshire deposits. The species occurring in the other cretaceous beds are also given; and other columns are devoted to those found in the Farringdon gravels, and in the cretaceous beds of the south-west of France. The series of strata is distinguished into 16 groups, whose aggregate thickness is upwards of 800 feet. (1) The lowest, or *Perna* beds, rise from the base of the cliff (near Atherfield Point), a short distance east of a point situated below the signal staff of the coastguard station, and form a ledge out at sea, called 'the bench,' which is visible at low water, and known to extend to a distance of several miles from the shore. These beds consist of a dark blue sandy clay and greenish sand, much harder in the upper than in the lower part, and characterised by abundance of *Perna Mulleti*, a fossil not occurring in any other part of the formation. Numerous remains of *Exogyra sinuata* are also found in this bed of large size, together with remains of fish belonging to the genera *Lamna, Odontaspis, Saurocephalus, Hypsodon, Hybodus*, &c. (2) The Atherfield clay is of a drab colour, passing into bluish grey, and contains flat nodular masses. *Ammonites, Pinna Robinaldina*, and turtle remains have been obtained from these nodules. (3) The Crackers. This group is especially remarkable for the great variety of its fossils. It consists of alternations of sandy clays and clays, and two layers of ferruginous sandy nodules, which have been called the "crackers" from the noise produced by the waves in dashing over the ledges formed by them on the shore. The lower part of this group is a brown clay and sand about 25 feet thick, and contains (amongst other fossils) calcareous deposits of *Ammonites*, and astacoid remains, the occurrence of which has caused it to be called by the collectors 'the lower lobster bed.' The succeeding beds are sands, containing concretionary masses of sandstone, and are about 20 feet thick, abounding in fossils throughout, amongst which *Pinna, Thetis, Ammonites Deshayesii*, and in the lower part *Myacites plicata* in an upright position, are the most plentiful. In the lower sandstone, from a foot to eighteen inches in thickness is almost entirely made up of *Gervillia aviculoides, Trigonia dædalea, Ammonites Deshayesii*, &c., while the upper layer of sandstone situated about a foot from the top of the sand, is composed of a coarse sandy limestone or grit, enclosing fossilized coniferous wood containing the remains of *Teredo*. The beds forming the remainder of this group are, in the lower part, a brown clay with astacoid fragments, 16 or 17 feet thick, and sandy clays for the rest of the distance, 23 or 24 feet. They contain fossils throughout. (4) A bed of brown or ferruginous coloured sand, 20 feet thick, forms the base of the 'lower *Exogyra* group,' and is overlain by two feet of sand containing *Perna alæformis*, but chiefly remarkable for the great abundance of *Terebratula sella*, which, though occurring in several of the beds higher up, is nowhere so plentiful as here. The bed with *Exogyra sinuata*, which comes to the shore under Atherfield High Cliff, is the next in succession. Where it comes to the base of the cliff it is about two feet thick—the lower 8 or 10 feet consisting of brown sand and sandstone with oolitic grains of iron ore. *Pinna Robinaldina* is often to be met with in the coarse sand at the bottom, while *Exogyra sinuata*, which is sometimes of very large size, chiefly abounds in the upper two feet. (5) The '*Scaphites* group' may be divided into three beds, the lowest of which is a brown and ferruginous coloured sand, 20 feet thick, containing large *Exogyra sinuata, Terebratula sella, Rhynchonella Gibbsiana*, and other fossils. The nodules containing *Scaphites gigas* and *S. Hillsii*, form layers about two feet in thickness, and are succeeded in ascending order by 27 feet of greenish sand with fine specimens of *Exogyra sinuata* in the upper part. (6) The 'lower *Crioceras* beds.' The lower layer rests upon the last-mentioned bed, and the remaining portion of this group of strata consists of three other layers containing *Crioceras*, imbedded in sand, the lowest of which, furnishing the best specimens of that fossil, crosses the bottom of Whale Chine. (7) The 'Walpen and Ladder Sands and clays' extend on the shore from about 30 yards east of Walpen Chine to about halfway between Ladder and Whale Chines, in the latter of which they are well seen; the lower 27 feet being a greenish sandy clay, with nodules containing *Ammonites Martini* and a large *Gryphæa*, and the upper part, about 33 feet, which is clayey below and sandy above, containing *Dentalium, Myacites mandibula, Pinna Robinaldina*, &c. (8) The 'Upper *Crioceras* group' is seen for some distance along the shore east of Walpen Chine. It consists of sandy nodules imbedded in sand, and containing *Crioceras Bowerbankii, Ammonites Martini, Gervillia solenoides, Terebratula sella*, and other fossils. (9) The 'Walpen and Ladder Sands' consist of greenish and grey sand, 42 feet thick, with a layer of large nodules at the base containing numerous fossils; about 6 feet above which is a bed of variable thickness, composed principally of *Serpulæ* associated with *Terebratula sella* and other shells. (10) The 'Second *Gryphæa* group.' In the lower 12 feet of sands and clays, some of which are ferruginous and oolitic, similar to those already noticed as forming the upper part of group 4, there are three or four ranges of *Exogyra sinuata*. That shell also occurs in the greenish sand forming the upper portion of this group, which marks the limits of its range in an upward direction. Small fragments of vegetable remains (*Lonchopteris Mantellii*) occur not only in these beds, but nearly throughout the whole formation. In the lowest part of this group they are associated with *Inoceramus*. (11) The 'Cliff-end Sands,' about 20 feet in thickness, consist of sands with a subordinate bed of fossiliferous clay with *Trigonia*, &c., in the lower part, and in the upper part of dark bluish clay and green sand, with pyritiferous concretions, some of which resemble the stems of plants. (12) 'Foliated Clay and Sand.' This division consists of 25 feet of alternations of dark blue clay and greenish sand, containing concretions of pyrites and large irregular masses of coarse sandstone. They are displayed in the cliffs between Walpen and Blackgang Chines, which between those two points are formed of hard greyish green sands, with three bands of ferruginous grit containing *Siphonia* like tubes, which on exposure to the air and action of the sea, assume a hollow, cavernous appearance from the wearing away of the softer portions. (13) 'Sands of Walpen and Blackgang Undercliff.' The commencement of this group is marked by a bed of loose white sand with thin laminæ of clay, about 8 feet 6 inches thick, which extends in the cliff as far as Walpen High Cliff, where it crops out at the surface of the ground. The remainder of the group consists of greenish and brown sand, 70 feet thick, succeeded by 7 feet of coarse ferruginous sand, with rounded grains of iron ore in the lower half of the bed, and by 12 feet of alternating sand and clay. (14) 'The ferruginous bands of Blackgang Chine' rise from the shore between Rocken End and Blackgang Chine; and form the uppermost fossiliferous group of the lower greensand formation. They are composed of brown and yellow sands, with layers of ferruginous concretions, and in the upper part of a bed of ferruginous sandstone, 5 feet thick, making about 20 feet for the thickness of the entire group, which is more or less fossiliferous throughout. (15) The 'Upper Clays and Sand-rock' consist of 40 feet of dark grey clay, with pyrites, separated by 18 feet of white and fawn coloured sand from a mass of clay and sand 60 feet thick. The sand rises from the base of the cliff about 200 yards west of Rocken End, near which it has been worked for glass-house purposes. (16) Various sands and clays constitue the remainder of the section, about half-way up in which is a bed of hard white sand, probably the same bed as that which appears at the base of the cliff on the shore at Rocken End. It there consists of 8 or 10 feet of hard white sand, with carbonaceous and ferruginous lines and harder, irregular ferruginous concretionary masses or bodies. This bed is at the top of the purely sandy deposits, and must constitute nearly the uppermost bed of the lower greensand formation. It appears on the face of the cliff, rising at an angle of from 2½° to 3° nearly as far as the top of Blackgang Chine, with blue clayey beds above. These clayey beds represent the gault. Near the junction of the greensand with the gault there is a layer of iron sandstone and a number of pyritised fossils and phosphatic nodules. The interpretation of this phenomenon presented in this section is given in a paper by Captain Ibbetson and Professor E. Forbes ('Quar. Jour. Geol. Soc.' vol. i.) to the following effect:—It appears that "at the close of the Wealden there was a sudden depression of the bed of the great fresh-water estuary and an influx of the sea. The first effect of such an influx would be the destruction of the animals in the estuary not adapted for living in salt water; hence we find a total destruction of the Wealden animals, the remains of which accumulate towards the junction of that formation with the lower greensand—a fact which indicates the nature of the change. Even the *Cerithium*, although belonging to a genus, many species of which are capable of living in the depths of the sea, was destroyed, notwithstanding that its appearance only in the uppermost beds of the Wealden indicates that its presence there was due to the commencement of the very state of things which eventually destroyed it. That the depression was of some extent, though not, perhaps, of many fathoms, is indicated by the nature of the animals which lived in the first formed sea-bed, and which, when they died, were often embedded, in the fine and probably fast depositing mud, in the vertical position in which it is the habit of such animals as *Pinna* and *Panopæa* to assume when alive. After this a temporary change followed, when an influx of sand mingling with the calcareous mud, caused a state of sea-bottom peculiarly favourable to the presence of animal life. In this way were called into existence a multitude of species, which were added to those which had appeared before these. This was, in fact, such a state of sea-bottom as is now presented by great shell banks; but it does not seem to have lasted long, and new depositions of mud appear to have extinguished some forms, whilst others suffered by the change only in the diminution of their numbers. In the midst of this muddy epoch, a temporary and peculiar condition of sea-bottom, forming what are called the 'crackers,' called forth the presence of numerous mollusca, at first of various species of the genus *Gervillia*, and of *Cerithium*, *Dentalium*, and other univalves, which appear to have enjoyed but a brief existence (as species) in this locality, since similar conditions were never afterwards repeated. The greater number of the gasteropodous mollusca of the English lower greensand are found within this range. At the close of the deposition of this great mass of clay there was for a time a great multiplication of individuals of certain brachiopoda, which had commenced their existence in the lower beds. Thus *Rhynchonella Gibbsii* suddenly appears in immense abundance, covering the bottom of the sea, and predominating over the animals among which it had previously been but thinly scattered. This lowest zone of *Terebratulæ* marks the commencement of a new state of sea-bottom where sands predominated over the clays, each interval of deposition being usually marked by the presence of a layer of *Exogyra sinuata*, the period of rest being almost always sufficient to enable the *Exogyra* to attain its full growth. Other bivalves are found with it, but in comparatively small numbers, and not such as are of gregarious habits. During the whole of this period enormous *Cephalopoda*, including species of *Crioceras* and *Scaphites*, frequented these seas, and when dead formed the nucleus round which calcareous and sandy matter collected and formed nodules. The death of these animals seems to have been connected with the periodical charging of the sea with sediment; hence we find them usually alternating with the zones of *Exogyra*, and forming irregular bands in the intervening sedimentary deposits. In the midst of the period of *Exogyra* there is a sudden re-appearance of the muddy deposits, during the predominance of which those animals adapted for such a sea-bottom, and which had survived the cessation of the deposition of the fuller's earth again multiplied, but the species which had become extinguished were not replaced by representative forms. This, however, did not last long, the sand again predominating with its zones of *Exogyra* and lines of *Crioceras* nodules. A temporary multiplication of *Terebratula sella* suddenly marks a change in the zoological conditions, for the *Cephalopoda* disappear, although the zones of *Exogyra*, which animal does not appear to have been affected by the change (probably a change in the depth of the sea), go on as before; there being, however, no alternating lines of nodules. It would seem that the sea began to shallow, probably from elevation of the sea-bottom, until at last the *Exogyra* itself disappears, the bands exhibit traces of the influence of currents, and become more gravelly; lignites, indicating a shallow sea, become common, form belts in the ferruginous sand, and in one place a bed in the wavy blue sand, at a time when much iron was deposited. The deposition of the peroxide of iron appears to have been connected with the disappearance of the majority of mollusca, though *Trigonia*, *Thetis*, and *Venus* occasionally occur in considerable numbers. In the uppermost strata scarcely any animal remains are found, and everything appears to indicate a barren and shallow sea, previous to a new state of things when a fresh series of clays (forming the gault) being deposited, the majority of the animal forms which characterise the clays of the lower greensand disappear, and are replaced by distinct species, representative in time." The gault of the Isle of Wight, then, strongly resembles the red chalk of Hunstanton in overlying a series of sterile sands, and in the marked difference of its fossils from the underlying fossiliferous strata. The remarkable fluctuations in the appearance and disappearance of the species pointed out in the quotation appears to be due to the migrations of faunas to localities newly adapted for them, but there is no proof that their appearance and disappearance is owing to their extinction and creation, an idea which pervades the quotation. It is one of the most difficult tasks in palæontology, a task which will tax the efforts of many generations of students, to determine the approximate periods when each species came into, and disappeared from existence. The following table represents the faunas of the Isle of Wight and south-west of France. The French species are stated on the authority of Coquand. The 'Gardonian' stage is considered to be intermediate between the lower chalk and chalk marl of England, the 'Carentonien' follows above, but is also older than the lower chalk; the lowermost portion of the chalk is believed to be absent. The next stage, the 'Angoumien' and the 'Provencien,' are not represented in England, but their age intervenes between the upper and lower halves of the lower chalk; the 'Coniacien' stage immediately underlies the 'superior lower chalk,' which is represented by the 'Santonien' stage; the 'Campanien' stage is equivalent to the upper chalk, and the 'Dordonien' belongs to the age immediately subsequent thereto. We have not attempted to reconcile the synonyms; but the table will afford an idea of the general character of the faunas:—

	ENGLAND (chiefly Isle of Wight).							FRANCE (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Plantæ.															
Actinophyllum ? sp.	*														
Lonchopteris Mantellii	*														
Chondrites fastigiatus	—	—	*												
Clathraria Lyellii	—	—	*												
Equisetites Bouchardii	—	—	—	—	—	—	*								
Fucoides Brardii	—	—	—	—	—	—	—	*							
F. Orbignyi	—	—	—	—	—	—	—	*							
F. striatus	—	—	—	—	—	—	—	*							
F. tuberculosus	—	—	—	—	—	—	—	*							
F. canaliculatus	—	—	—	—	—	—	—	*							
Zosterites caulinisofolia	—	—	—	—	—	—	—	*							
Z. lineata	—	—	—	—	—	—	—	*							
Z. bellovisana	—	—	—	—	—	—	—	*							
Z. elongata	—	—	—	—	—	—	—	*							
Protozoa.															
Foraminifera.															
Cyclolina cretacea	—	—	—	—	—	—	—	—	*						
Orbitolina plana	—	—	—	—	—	—	—	—	*						
O. mamillata	—	—	—	—	—	—	—	—	*						
O. concava	—	—	—	—	—	—	—	—	*						
Dentalina rustica	—	—	—	—	—	—	—	—	*						
Cristellaria carentina	—	—	—	—	—	—	—	—	*						
Lituola rugosa	—	—	—	—	—	—	—	—	*						
Alveolina cretacea	—	—	—	—	—	—	—	—	*						
A. ovum	—	—	—	—	—	—	—	—	*						
Chrysalidina gradata	—	—	—	—	—	—	—	—	*						
Cuneolina pavonia	—	—	—	—	—	—	—	—	*						
C. conica	—	—	—	—	—	—	—	—	*						
C. Fleuriaui	—	—	—	—	—	—	—	—	*						
Orbitolites media	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Orbitolina gigantea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. radiata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Spongidæ.															
Conis contortuplicata	*														

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Spongia peziza	—	*													
Manon marginatum	—	*													
M. macropora	—	*													
M. porcatum	—	*													
M. farringdonense	—	*													
Scyphia foraminosa	—	*													
S. furcata	—	*													
Jerea Desnoyeri	—	*													
Verticellites anastomosans	—	*													
Siphonia pyriformis	—	—	—	*											
S. Websteri	—	—	—	*											
S. agariciformis	—	—	—	—	*										
Spongia meandroides	—	—	—	—	*										
Scyphia Fittoni	—	—	—	—	*										
Cliona Mantellii	—	—	—	—	—	—	*								
Hippalimus fungioides	—	—	—	—	—	—	—	—	*						
Stellispongia microstella	—	—	—	—	—	—	—	—	*						
Amorphospongia carentonensis	—	—	—	—	—	—	—	—	*						
A. Gaudryi	—	—	—	—	—	—	—	—	*						
A. digitata	—	—	—	—	—	—	—	—	*						
Siphonia Fittoni	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. Kœnigii	—	—	—	—	—	—	—	—	—	—	—	—	*		
Jerea cupula	—	—	—	—	—	—	—	—	—	—	—	—	*		
Marginospongia irregularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cupulospongia dilatata	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. towensensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. oblonga	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Verticellites Goldfussi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Siphonia lycoperdites	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Spargispongia rugosissima	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Cliona irregularis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Rhyzospongia pictonica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Cœlenterata.															
Actinozoa.															
Chisma furcillatum	*														
Choristopetalum impar	*														
Cyathophora elegans	*														
Holocystis elegans	*														
Siphodictyum gracile	*														
Ellipsosmilia cornucopiæ	—	—	—	—	—	—	—	—	*						
E. humilis	—	—	—	—	—	—	—	—	*						
Lasmophyllia pateriformis	—	—	—	—	—	—	—	—	*						
L. meandra	—	—	—	—	—	—	—	—	*						
Cœlosmilia sulcata	—	—	—	—	—	—	—	—	*						
Funginella elegans	—	—	—	—	—	—	—	—	*						
Amblophyllia cretacea	—	—	—	—	—	—	—	—	*						
Dactylosmilia carentonensis	—	—	—	—	—	—	—	—	*						
Barysmilia confusa	—	—	—	—	—	—	—	—	*						
Cyclocœnia rustica	—	—	—	—	—	—	—	—	*						
Cryptocœnia carantoniana	—	—	—	—	—	—	—	—	*						
C. Fleuriaui	—	—	—	—	—	—	—	—	*						
C. rustica	—	—	—	—	—	—	—	—	*						
Stephanocœnia coniacensis	—	—	—	—	—	—	—	—	*						
S. grandipora	—	—	—	—	—	—	—	—	*						
S. carantonensis	—	—	—	—	—	—	—	—	*						
S. littoralis	—	—	—	—	—	—	—	—	*						
S. Fleuriaui	—	—	—	—	—	—	—	—	*						
Astrocœnia carentonensis	—	—	—	—	—	—	—	—	*						
Synastrea pinnata	—	—	—	—	—	—	—	—	*						
Centrastrea cenomana	—	—	—	—	—	—	—	—	*						
C. Michelini	—	—	—	—	—	—	—	—	*						
Stelloria rustica	—	—	—	—	—	—	—	—	*						
S. elegans	—	—	—	—	—	—	—	—	*						
Polytremacis bulbosa	—	—	—	—	—	—	—	—	*						
Dactylacis ramosa	—	—	—	—	—	—	—	—	*						
Cyclolites elliptica	—	—	—	—	—	—	—	—	—	—	*				
Funginella hemisphærica	—	—	—	—	—	—	—	—	—	—	*				
Ellipsosmilia cuneolus	—	—	—	—	—	—	—	—	—	—	*				
Phyllocœnia pediculata	—	—	—	—	—	—	—	—	—	—	*				
Astrocœnia formosa	—	—	—	—	—	—	—	—	—	—	*				
Astræa sulcato-lamellosa	—	—	—	—	—	—	—	—	—	—	*				
Synastræa cistela	—	—	—	—	—	—	—	—	—	—	*				
S. microxona	—	—	—	—	—	—	—	—	—	—	*				
Mæandrina radiata	—	—	—	—	—	—	—	—	—	—	*				
Polytrema Coquandi	—	—	—	—	—	—	—	—	—	—	*				
P. pavonia	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. mæandrea	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. avellana	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. dilatata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cyclolites cancellata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. cupularia	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Diploctenium subcirculare	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
D. lamellosum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Aplosastræa gemminata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	*
Astræa royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Ceriopora subdichotoma	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. cryptopora	—	—	—	—	—	—	—	—	—	—	—	—	—	*	*
Polytrema sphæra	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. urceolata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Millepora glomerata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cryptocœnia rotula	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Synastræa filamentosa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Actinhelia elegans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Ceriopora madreporacea	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
C. racemosa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Annulosa.															
Echinodermata.															
Brissus sp.	*														
Cardiaster Benstedi	*														
Diadema Autissodorense	*														
D. Ibbetsoni	*														
Hemipneustes Fittoni	*														
Nucleolites Olfersii	*														
Salenia punctata?	*	*													
Schizaster D'Urbani?	?*														
Diadema dubium	—	*													
Cidaris sp.	—	*													
Ananchytes lævis	—	—	—	—	*										
Catopygus carinatus	—	—	—	—	*	—	—	—	*						
Discoidea subuculus	—	—	—	—	*										
D. cylindrica	—	—	—	—	—	*									
Ananchytes ovatus	—	—	—	—	—	—	*	—	—	—	—	—	—	*	
A. planus	—	—	—	—	—	—	*								
Cidaris vesiculosa	—	—	—	—	—	—	*								
Galerites albogalerus	—	—	—	—	—	—	*								
Micraster cor-anguinum	—	—	—	—	—	—	*	—	*	—	—	—	—	*	
Goniopygus Menardi	—	—	—	—	—	—	—	—	*						
G. globosus	—	—	—	—	—	—	—	—	*						
G. major	—	—	—	—	—	—	—	—	*						
Cottaldia granulosa	—	—	—	—	—	—	—	—	*						
Peltastes acanthodes	—	—	—	—	—	—	—	—	*						
Salenia personata	—	—	—	—	—	—	—	—	*						
Pygaster truncatus	—	—	—	—	—	—	—	—	*						
Discoidea excisa	—	—	—	—	—	—	—	—	*	—	—	—	*		
Anorthopygus costellatus	—	—	—	—	—	—	—	—	*						
Caratomus faba	—	—	—	—	—	—	—	—	*						
C. rostratus	—	—	—	—	—	—	—	—	*						
C. trigonopygus	—	—	—	—	—	—	—	—	*						
C. latirostris	—	—	—	—	—	—	—	—	*						
Pygaulus subequalis	—	—	—	—	—	—	—	—	*						
P. macropygus	—	—	—	—	—	—	—	—	*						
Catopygus columbarius	—	—	—	—	—	—	—	—	*						
C. obtusus	—	—	—	—	—	—	—	—	*						
Nucleolites similis	—	—	—	—	—	—	—	—	*						
Pygurus lampas	—	—	—	—	—	—	—	—	*						
Archiacia santonensis	—	—	—	—	—	—	—	—	*						
A. gigantea	—	—	—	—	—	—	—	—	*						
A. sandalina	—	—	—	—	—	—	—	—	*						
Micraster Michelini	—	—	—	—	—	—	—	—	*						
Holaster carinatus	—	—	—	—	—	—	—	—	*						
H. suborbicularis	—	—	—	—	—	—	—	—	*						
H. cenomanensis	—	—	—	—	—	—	—	—	*						
Hemiaster similis	—	—	—	—	—	—	—	—	*						
H. Leymerii	—	—	—	—	—	—	—	—	*						
H. nucleus	—	—	—	—	—	—	—	—	*						
H. Verneuili	—	—	—	—	—	—	—	—	*						
H. Orbignyi	—	—	—	—	—	—	—	—	*						
Periaster elatus	—	—	—	—	—	—	—	—	*						
P. undulatus	—	—	—	—	—	—	—	—	*						
P. conicus	—	—	—	—	—	—	—	—	*						
Phymosoma regulare	—	—	—	—	—	—	—	—	—	—	—	*	*	*	
Holectypus turonensis	—	—	—	—	—	—	—	—	—	—	—	*			
Nucleopygus depressus	—	—	—	—	—	—	—	—	—	—	—	*			
Micraster consobrinus	—	—	—	—	—	—	—	—	—	—	—	*			
Pentacrinus carinatus	—	—	—	—	—	—	—	—	—	—	—	*			
Pseudodiadema Kleinii	—	—	—	—	—	—	—	—	—	—	—	—	*		
Diplopodia Archiaci	—	—	—	—	—	—	—	—	—	—	—	—	*		
D. variolaris	—	—	—	—	—	—	—	—	—	—	—	—	*		
D. subnuda	—	—	—	—	—	—	—	—	—	—	—	—	*		
Phymosoma carentonianum	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. rugosum	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. sulcatum	—	—	—	—	—	—	—	—	—	—	—	—	*	*	
Salenia scutigera?	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. gibba	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. geometrica	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. heliopora	—	—	—	—	—	—	—	—	—	—	—	—	*		
Galerites vulgaris	—	—	—	—	—	—	—	—	—	—	—	—	*		
Pyrina ovata	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. ovulum	—	—	—	—	—	—	—	—	—	—	—	—	*	*	
Rhynchopygus galeatus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Holaster semistriatus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Micraster brevis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Micraster laxoporus	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. rostratus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Hemiaster nasutulus	—	—	—	—	—	—	—	—	—	—	—	—	*		
H. angustipneustes	—	—	—	—	—	—	—	—	—	—	—	—	*		
Nucleolites parallelus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cidaris cyathifera	—	—	—	—	—	—	—	—	—	—	—	—	*	*	
C. vendocinensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Bourgueticrinus ellipticus	—	—	—	—	—	—	—	—	—	—	—	—	*	*	

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdou Gravel.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Cidaris clavigera	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. sceptrifera	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. subvesiculosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Ramondi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. granulostriata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Jouanneti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. spinosissima	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Phymosoma corollare	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. magnificum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. saxatile	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. circinnatum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Saemanni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. girumnense	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Kœnigii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. ornatissimum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Pseudodiadema pusillum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. miliare	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Goniopygus Baylei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cottaldia Michelini	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Psammechinus Desori	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Hyposalenia heliophora	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Discoidea lævissima	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Globator petrocoriensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Echinobrissus minor	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Moulinsii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Collegnii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Nucleolites crucifer	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Botriopygus Nanclasi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Catopygus elongatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Rhynchopygus Marmini	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Faujassia Faujassi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Conoclypus Leskei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. acutus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. ovum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cardiaster ananchytes	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Hemipneustes radiatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Micraster Leskei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
M. integer	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Hemiaster prunella	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
H. Könincki	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
H. breviusculus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
H. Moulinsi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Pentetagonaster stratiferus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. chiliporus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Moulinsii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. punctulatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Bourgueticrinus æqualis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Annelida.															
Serpula antiquata	*														
S. filiformis	*														
S. plexus	*	*													
S. polygonalis	*														
S. Richardi	*														
Vermicularia concava	—	—	—	*											
Crustacea.															
Astacus vectensis	*														
Meyeria magna	*														
Mithracites vectensis	*														
Fragments	—	—	—	—	—	—	—	—	*	—	—	*			
Galeoria Arnaudi	—	—	—	—	—	—	—			—	—	—	*		
Mollusca.															
Polyzoa.															
Domopora tuberculata	—	*													
Ceriocava ramulosa	—	*													
Heteropora cryptopora	—	*													
Ceriopora polymorpha	—	*													
Entalophora meudonensis	—	*													
Biflustra carentina	—	—	—	—	—	—	—	—	*						
Membranipora cenomana	—	—	—	—	—	—	—	—	*						
Melicertites compressa	—	—	—	—	—	—	—	—	*						
Entalophora carentina	—	—	—	—	—	—	—	—	*						
Stomatopora reticulata	—	—	—	—	—	—	—	—	*						
Berenicea regularis	—	—	—	—	—	—	—	—	*						
Unicavea subradiata	—	—	—	—	—	—	—	—	*						
Domopora clavula	—	—	—	—	—	—	—	—	*						
Radiopora pustulosa	—	—	—	—	—	—	—	—	*						
R. Huoti	—	—	—	—	—	—	—	—	*						
Cellarina turonensis	—	—	—	—	—	—	—	—	—	*					
Fusicellaria pulchella	—	—	—	—	—	—	—	—	—	*					
Vincularia quadrilatera	—	—	—	—	—	—	—	—	—	*					
V. ponsiana	—	—	—	—	—	—	—	—	—	*					
Eschara echinata	—	—	—	—	—	—	—	—	—	*					
Escharipora chrysalis	—	—	—	—	—	—	—	—	—	*					
Biflustra inæqualis	—	—	—	—	—	—	—	—	—	*					
B. simplex	—	—	—	—	—	—	—	—	—	*					
B. ogivalis	—	—	—	—	—	—	—	—	—	*					
B. ligeriensis	—	—	—	—	—	—	—	—	—	*					
B. meudonensis	—	—	—	—	—	—	—	—	—	*					
B. heteropora	—	—	—	—	—	—	—	—	—	*					
B. gracilis	—	—	—	—	—	—	—	—	—	*					
Filiflustra compressa	—	—	—	—	—	—	—	—	—	*					
Flustrella pulchella	—	—	—	—	—	—	—	—	—	*	—	—	—	—	*
F. regularis	—	—	—	—	—	—	—	—	—	*					

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravel.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Flustrella irregularis	—	—	—	—	—	—	—	—	—	*					
Flustrina transversa	—	—	—	—	—	—	—	—	—	*					
F. triforata	—	—	—	—	—	—	—	—	—	*					
Semieschara inornata	—	—	—	—	—	—	—	—	—	*					
Cellepora santonensis	—	—	—	—	—	—	—	—	—	*					
Flustrellaria Franquana	—	—	—	—	—	—	—	—	—	*					
Membranipora ovalis	—	—	—	—	—	—	—	—	—	*					
Melicertites foricula	—	—	—	—	—	—	—	—	—	*					
Semielea Vielbanci	—	—	—	—	—	—	—	—	—	*					
Reptelea pulchella	—	—	—	—	—	—	—	—	—	*					
Laterotubigera flexuosa	—	—	—	—	—	—	—	—	—	*					
Idmonea carantina	—	—	—	—	—	—	—	—	—	*					
I. lata	—	—	—	—	—	—	—	—	—	*					
Entalophora inconstans	—	—	—	—	—	—	—	—	—	*					
Filisparsa reticulata	—	—	—	—	—	—	—	—	—	*					
Discosparsa cupula	—	—	—	—	—	—	—	—	—	*					
Proboscina radiolitorum	—	—	—	—	—	—	—	—	—	*					
Claviclausa elegans	—	—	—	—	—	—	—	—	—	*					
Cavea regularis	—	—	—	—	—	—	—	—	—	*					
Sparsicavea carantina	—	—	—	—	—	—	—	—	—	*					
Truncatula alternata	—	—	—	—	—	—	—	—	—	*					
Filicrisina verticillata	—	—	—	—	—	—	—	—	—	*					
Reptomulticavea mamilla	—	—	—	—	—	—	—	—	—	*					
Ceriopora digitata	—	—	—	—	—	—	—	—	—	—	—	*			
Numerous fragments	—	—	—	—	—	—	—	—	—	—	—	*			
Eschara Acis	—	—	—	—	—	—	—	—	—	—	—	—	*	—	*
E. Aegle	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. Aegon	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. amata	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. cypræa	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. cytherea	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. Aegea	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. Agata	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. Claudia	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. Electra	—	—	—	—	—	—	—	—	—	—	—	—	*		
Quadricellaria elegans	—	—	—	—	—	—	—	—	—	—	—	—	*		
Q. pulchella	—	—	—	—	—	—	—	—	—	—	—	—	*		
Vincularia multicella	—	—	—	—	—	—	—	—	—	—	—	—	*		
V. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
V. perforata	—	—	—	—	—	—	—	—	—	—	—	—	*		
V. peregrina	—	—	—	—	—	—	—	—	—	—	—	—	*		
V. longicella	—	—	—	—	—	—	—	—	—	—	—	—	*		
Escharipora insignis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Biflustra tuberculata	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. mæandrina	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. variabilis	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. æqualis	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. allita	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. bimarginata	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. grandis	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. lacrymopora	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. cyclopora	—	—	—	—	—	—	—	—	—	—	—	—	*		
B. marginata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Frustrella frondosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. subcylindrica	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. echinata	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. rhomboidalis	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. terminalis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Flustrina constricta	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. spatulata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Lunulites Bourgeoisi	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. cretacea	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. plana	—	—	—	—	—	—	—	—	—	—	—	—	*		
Reptolunulites angulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Pavolunulites elegans	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semieschara grandis	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. arborea	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. dentata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cellepora parisiensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. Vesta	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. Clio	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. Thisbe	—	—	—	—	—	—	—	—	—	—	—	—	*		
Porina filograna	—	—	—	—	—	—	—	—	—	—	—	—	*		
Repteschareila inæqualis	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. radiata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semiescharipora interrupta	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. irregularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Steginopora irregularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Flusirellaria cretacea	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. oblonga	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. bipunctata	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. tubulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
F inornata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Membranipora Franquana	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. gracilis	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. ligeriensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. normaniana	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. cypris	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. concatenata	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. rhomboidalis	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. marginata	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. strangulata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Filiflustrella lateralis	—	—	—	—	—	—	—	—	—	—	—	—	*		

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Reptoflustrina simplex	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. tubulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Nodelea semiluna	—	—	—	—	—	—	—	—	—	—	—	—	*		
Multinodelea tuberosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Melicostites meudonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Elea lamellosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Multelea magnifica	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semielea plana	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semimultelea arborescens	—	—	—	—	—	—	—	—	—	—	—	—	*		
Foricula spinosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
F. aspera	—	—	—	—	—	—	—	—	—	—	—	—	*		
Filifascigera dichotoma	—	—	—	—	—	—	—	—	—	—	—	—	*		
Reptofascigera alternata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Fasciporina flexuosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Peripora ligeriensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Spiropora antiqua	—	—	—	—	—	—	—	—	—	—	—	—	*		
Laterotubigera macropora	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. transversa	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. annulato-spiralis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Clavitubigera convexa	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. angustata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Idmonea excavata	—	—	—	—	—	—	—	—	—	—	—	—	*		
I. communis	—	—	—	—	—	—	—	—	—	—	—	—	*		
I. grandis	—	—	—	—	—	—	—	—	—	—	—	—	*		
I. marginata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semi-laterotubigera annulata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Reptotubigera ramosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. elevata	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. marginata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Radiotubigera organisans	—	—	—	—	—	—	—	—	—	—	—	—	*		
Discotubigera santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Unitubigera papyracea	—	—	—	—	—	—	—	—	—	—	—	—	*		
Actinopora Gaudryi	—	—	—	—	—	—	—	—	—	—	—	—	*		
Entalophora raripora	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. linearis	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. subregularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
E. pustulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Mesinteriopora auricularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Discosparsa clypeiformis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Diastopora papyracea	—	—	—	—	—	—	—	—	—	—	—	—	*		
D. tubulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Stomatopora ramea	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. Calypso	—	—	—	—	—	—	—	—	—	—	—	—	*		
Proboscina Toucasi	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. fasciculata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Berenicea papillosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Multisparsa foliacea	—	—	—	—	—	—	—	—	—	—	—	—	*		
Reptomultisparsa congesta	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semimultisparsa tuberosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Reptoclausa obliqua	—	—	—	—	—	—	—	—	—	—	—	—	*		
Claviclausa globulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Multiclausa compressa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Clausa micropora	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. obliqua	—	—	—	—	—	—	—	—	—	—	—	—	*		
Reticulipora obliqua	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. ligeriensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Crisina triangularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cavea royana	—	—	—	—	—	—	—	—	—	—	—	—	*		
Clavicavea regularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Discocavea irregularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semicea tubulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Semicavea variabilis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Ditaxia anomalopora	—	—	—	—	—	—	—	—	—	—	—	—	*		
Lichenopora elatior	—	—	—	—	—	—	—	—	—	—	—	—	*		
Unicavea collis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Filicea sub-compressa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Laterocea simplex	—	—	—	—	—	—	—	—	—	—	—	—	*		
Reptomulticavea simplex	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. subirregularis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Truncatula carinata	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. gracilis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Unicytia falcata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Nodicressis tuberculata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cellaria cactiformis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. inæqualis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Vincularia normaniana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. regularis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. rustica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. pulchella	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. verticillata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. lepida	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. elegans	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. Leda	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. quadrangularis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Eschara Delaruei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. girondina	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Eschara santonensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Antiopa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Aglaia	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Allica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Artemis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Callirhoo	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Calypso	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Camilla	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Camæna	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Cassiopo	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Cepha	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Charonia	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Chloris	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. Dejanira	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Escharinella elegans	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Escharifora Circe	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. rhomboidalis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Escharella Arge	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Escharipora Neptuni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. pretiosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Biflustra Actæon	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. crassoramosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. regularis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. rhomboidalis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. rustica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. prolifica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. pauperata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. girondina	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Flustrella polymorpha	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. inversa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Flustrina compressa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. elegans	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. ornata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Stichopora clypeata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Semieschara simplex	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cellepora simplex	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Zelima	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Zangis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Xiphia	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Urania	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Porina angustata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. varians	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. filiformis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Repteschareliina horrida	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. flabellata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. pupoides	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Semieschanpora ovalis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Repteschanpora rustica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Discoflustrellaria doma	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Filiflustrellaria obliqua	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Flustrellaria forata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. profunda	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Membranipora Calypso	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
M. subsimplex	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
M. pyriformis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
M. rustica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Nodelea ornata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Melicertites semiluna	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Osculipora royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Tubigera antiqua	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Idmonea ramosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
I. cancellata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
I. pseudodisticha	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Reptotubigera serpens	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Multitubigera gregarea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Entalophora subgracilis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. madreporacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. symmetrica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Bidiastopora elegans	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. crassa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. triangulacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
B. papyracea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Mesinteriopora laxopora	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Berenicea littoralis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Spiroclausa spiralis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Clausa irregularis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Reticulipora girondina	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Bicrisina cultrata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Crisina normaniana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Zonopora variabilis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Z. undata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Reteporidea royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. ramosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Multicavea magnifica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Sulcocavea lacryma	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Plethopora ramulosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. cervicornis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Semicressis tubulosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Brachiopoda.															
Lingula truncata	*														
Rhynchonella depressa	*	*													
R. Gibbsiana	*														
R. latissima	*	*													
R. nuciformis	*	*	—	—	*										
R. parvirostrum	*														
R. sulcata	*														

	ENGLAND (chiefly Isle of Wight).							FRANCE (South-west).							
	Lower Greensand.	Farringdon Gravel.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Terebratula celtica	*														
T. faba	*														
T. lentoidea	*														
T. oblonga	*														
T. sella	*														
T. depressa	—	*													
T. nerviensis	—	*													
T. Boubei	—	*													
T. Roemeri	—	*													
T. revoluta	—	*													
Terebratella Menardi	—	*	—	—	—	—	—	—	*						
Rhynchonella compressa	—	—	—	*	—	—	—	—	*						
Terebratella pectita	—	—	—	—	*	—	—	—	*						
Terebratula biplicata	—	—	—	—	*	—	—	—	*						
Magas pumila	—	—	—	—	—	—	*								
Rhynchonella Lamarckii	—	—	—	—	—	—	—	—	*						
R. contorta	—	—	—	—	—	—	—	—	*						
Terebratula phaseolina	—	—	—	—	—	—	—	—	*						
Terebratella carentonensis	—	—		—	—	—	—	—	*						
Rhynchonella vespertilio	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. Eudesii	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. difformis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Terebratula Nanclasi	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. echinulata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Terebratella coniacensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. Fajoli	—	—	—	—	—	—	—	—	—	—	—	—	*		
Terebratula semiglobosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Rhynchonella triptera	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. Boreaui	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. Blutelii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. octoplicata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. vesicularis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Terebratula Boucheroni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. Clementi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. orthisiformis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Crania Ignabergensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Heberti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Discina lamellosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Lamellibranchiata.															
Anomia convexa	*														
A. lævigata	*														
A. radiata	*														
Avicula depressa	*														
A. ephemera	*														
A. lanceolata	*														
A. pectinata	*														
Exogyra harpa	*	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. plicata	*	—	—	—	—	—	—	—	—	—	—	—	—	*	
E. sinuata	*														
Gervillia alæformis	*														
G. anceps	*														
G. aviculoides	*														
G. forbesiana	*														
G. linguloides	*														
G. solenoides	*														
Hinnites Leymerici	*														
Inoceramus concentricus	*	—	*	*											
I. neocomiensis	*														
Lima Cottaldina	*														
L. elongata	*	—	—	—	*										
L. semisulcata	*	—	—	—	—	—	—	—	—	—	—	*	—	*	
L. undata	*														
L. sp.?	*														
Ostrea frons	*	—	—	—	*	—	—	—	—	—	—	—	*		
O. Leymerici	*														
O. macroptera	*	*													
O. retusa	*														
Pecten interstriatus	*	*													
P. orbicularis	*	—	—	*											
P. quinquecostatus	*	—	*	*	*										
P. robinaldinus	*														
P. sp.	*														
Perna Mulleti	*														
P. ricordiana	*														
P. Galieni	*														
P. robinaldina	*														
Plicatula carteroniana	*														
Arca Carteroni	*														
A. cornueliana	*														
A. dupiniana	*														
A. Raulini	*														
A. securis	*														
Astarte Beaumontii	*														
A. numismalis	*														
A. obovata	*														
A. rostrata	*														
A. striatocostata	*														
A. substriata	*														
A. sp.	*														
Cardita neocomiensis	*														
C. quadrata	*														
Cardium Austeni	*														
C. cornuelianum	*														
C. Ibbetsoni	*														

	ENGLAND (chiefly Isle of Wight).							FRANCE (South-west).							
	Lower Greensand.	Farringdon Gravel.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Cardium imbricatorum	*														
C. peregrinosum	*														
C. raulinianum	*														
C. sphaeroideum	*														
C. subhillanum	*														
C. Voltzii	*														
Sphæra corrugata	*														
Corbis fibrosa	*														
Corbula striatula	*														
Cucullæa Gabrielis	*														
Cypricardia undulata	*														
Cyprina angulata	*														
Leda ligeriensis	*														
Cytherea parva	*														
Diceras Lonsdalii	*														
Gastrochæna dilatata	*														
Isocardia ornata	*														
Leda scapha	*														
L. spathulata	*														
Lithodomus oblongus	*														
Lucina dupiniana	*														
L. globiformis	*														
L. solidula	*														
Mactra Carteroni	*														
Modiola æqualis	*														
M. bella	*														
M. d'Archiaci?	*														
M. simplex	*														
Myacites elongata	*	—	—	*											
M. mandibula	*	—	*	*											
M. neocomiensis	*														
M. plicata	*														
Mytilus lanceolatus	*														
M. l. var. edentulus	*														
Nucula antiquata	*														
Pholadomya Agassizii	*														
P. Martini	*														
Pholas prisca	*														
Solecurtus Warburtoni	*														
Tellina? angulata	*														
T. Carteroni	*														
T. vectiana	*														
Thetis major	*	—	—	*											
T. minor	*														
T. Sowerbii?	*														
Trigonia alæformis	*														
T. carinata	*	—	—	*											
T. elongata	*														
T. caudata	*	—	—	*											
T. dædalea	*														
T. nodosa	*														
T. ornata	*														
T. spectabilis	*														
T. spinosa	*	—	—	*											
T. sulcata	*														
Venus brongniartiana	*														
V. caperata	*														
V. cornueliana	*														
V. fenestrata	*														
V. orbigniana	*														
V. ovalis	*														
V. ricordiana	*														
V. striato-costata	*														
V. vectensis	*														
Ostrea vesicularis	—	*	—	—	—	—	—	—	—	—	—	—	—	*	
Exogyra conica	—	*	—	—	—	—	—	—	—	—	—	—	—	*	
Lima farringdonensis	—	*													
Pecten quadricostatus	—	—	*												
Inoceramus sulcatus	—	—	*												
Gryphæa conica	—	—	—	*											
G. vesiculosa	—	—	—	*											
Inoceramus lævigatus	—	—	—	*											
I. tenuis	—	—	—	*											
Lima Hoperi	—	—	—	*											
Pecten asper	—	—	—	*											
Pinna tetragona	—	—	—	*											
Plicatula inflata	—	—	—	*	*	—	*								
Arca carinata	—	—	—	*											
Cardium gentianum	—	—	—	*											
Inoceramus Cuvieri	—	—	—	—	—	*	*								
Pecten Beaveri	—	—	—	—	—	*									
Pholadomya decussata	—	—	—	—	—	*									
Inoceramus mytiloides	—	—	—	—	—	—	*	—	—	—	—	—	*		
I. undulatus	—	—	—	—	—	—	*								
Lima spinosa	—	—	—	—	—	—	*								
Teredo Fleuriausi	—	—	—	—	—	—	—	*							
Panopæa substriata	—	—	—	—	—	—	—	—	*						
Solen carentonensis	—	—	—	—	—	—	—	—	*						
Tellina discrepans	—	—	—	—	—	—	—	—	*						
Mytilus engolimensis	—	—	—	—	—	—	—	—	*						
M. interruptus	—	—	—	—	—	—	—	—	*						
M. inornatus	—	—	—	—	—	—	—	—	*						
M. subfalcatus	—	—	—	—	—	—	—	—	*						
M. ligeriensis	—	—	—	—	—	—	—	—	*						
Lithodomus carentonensis	—	—	—	—	—	—	—	—	*						
L. suborbicularis	—	—	—	—	—	—	—	—	*						
L. Coquandi	—	—	—	—	—	—	—	—	*						
Lima intermedia	—	—	—	—	—	—	—	—	*						
L. varusensis	—	—	—	—	—	—	—	—	*						
L. Boreaui	—	—	—	—	—	—	—	—	*						
L. simplex	—	—	—	—	—	—	—	—	*						
L. subconsobrina	—	—	—	—	—	—	—	—	*						

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Lima subabrupta	—	—	—	—	—	—	—	—	*						
L. cenomanensis	—	—	—	—	—	—	—	—	*						
L. ornata	—	—	—	—	—	—	—	—	*						
Pecten elongatus	—	—	—	—	—	—	—	—	*						
P. subacutus	—	—	—	—	—	—	—	—	*						
P. virgatus	—	—	—	—	—	—	—	—	*						
Janira dilatata	—	—	—	—	—	—	—	—	*						
J. phaseola	—	—	—	—	—	—	—	—	*						
J. Fleuriausi	—	—	—	—	—	—	—	—	*						
J. carentonensis	—	—	—	—	—	—	—	—	*						
Cyprina Neptuni	—	—	—	—	—	—	—	—	*						
C. oblonga	—	—	—	—	—	—	—	—	*						
Lucina Nereis	—	—	—	—	—	—	—	—	*						
Avicula anomala	—	—	—	—	—	—	—	—	*						
Cardium Carolinum	—	—	—	—	—	—	—	—	*						
C. Guerangeri	—	—	—	—	—	—	—	—	*						
Myoconcha cretacea	—	—	—	—	—	—	—	—	*						
M. angulata	—	—	—	—	—	—	—	—	*						
Isocardia carentonensis	—	—	—	—	—	—	—	—	*						
Crassatella Guerangeri	—	—	—	—	—	—	—	—	*						
C. vindinnensis	—	—	—	—	—	—	—	—	*						
Chama navis	—	—	—	—	—	—	—	—	*						
C. Delaruei	—	—	—	—	—	—	—	—	*						
C. ornata	—	—	—	—	—	—	—	—	*						
C. lævigata	—	—	—	—	—	—	—	—	*						
C. carentonensis	—	—	—	—	—	—	—	—	*						
C. rugosa	—	—	—	—	—	—	—	—	*						
Spondylus hystrix ?	—	—	—	—	—	—	—	—	*	*					
Arca Noueli	—	—	—	—	—	—	—	—	*						
A. ligeriensis	—	—	—	—	—	—	—	—	*						
A. tailleburgensis	—	—	—	—	—	—	—	—	*						
A. Guerangeri	—	—	—	—	—	—	—	—	*						
A. Archiaci	—	—	—	—	—	—	—	—	*						
Trigonia scabra ?	—	—	—	—	—	—	—	—	*						
T. sinuata	—	—	—	—	—	—	—	—	*						
T. Pyrrha	—	—	—	—	—	—	—	—	*						
T. nereis	—	—	—	—	—	—	—	—	*						
Limopsis Guerangeri	—	—	—	—	—	—	—	—	*						
Pinna Gallieni	—	—	—	—	—	—	—	—	*						
Inoceramus problematicus ?	—	—	—	—	—	—	—	—	*						
I. striatus ?	—	—	—	—	—	—	—	—	*						
I. sublabiatus :	—	—	—	—	—	—	—	—	*						
Ostrea columba	—	—	—	—	—	—	—	—	*						
O. Reaumuri	—	—	—	—	—	—	—	—	*						
O. pernoides	—	—	—	—	—	—	—	—	*						
O. diluviana	—	—	—	—	—	—	—	—	*						
O. hippopodium	—	—	—	—	—	—	—	—	*						
O. haliotidea	—	—	—	—	—	—	—	—	*						
O. lingularis	—	—	—	—	—	—	—	—	*						
O. carentonensis	—	—	—	—	—	—	—	—	*						
O. flabella	—	—	—	—	—	—	—	—	*						
O. carinata	—	—	—	—	—	—	—	—	*						
O. biauriculata	—	—	—	—	—	—	—	—	*						
O. Lesueuri	—	—	—	—	—	—	—	—	*						
O. lateralis	—	—	—	—	—	—	—	—	*						
O. Baylei	—	—	—	—	—	—	—	—	*						
Sphærulites triangularis	—	—	—	—	—	—	—	—	*						
S. foliaceus	—	—	—	—	—	—	—	—	*						
S. Fleuriausi	—	—	—	—	—	—	—	—	*						
S. Sharpei	—	—	—	—	—	—	—	—	*						
Caprina polyconillites	—	—	—	—	—	—	—	—	*						
C. adversa	—	—	—	—	—	—	—	—	*						
C. quadripartita	—	—	—	—	—	—	—	—	*						
C. striata	—	—	—	—	—	—	—	—	*						
C. costata	—	—	—	—	—	—	—	—	*						
C. triangularis	—	—	—	—	—	—	—	—	*						
Venus Noueli	—	—	—	—	—	—	—	—	—	*					
Cardium guttiferum	—	—	—	—	—	—	—	—	—	*					
C. productum	—	—	—	—	—	—	—	—	—	*					
Chama Archiaci	—	—	—	—	—	—	—	—	—	*					
Ostrea Rochebruni	—	—	—	—	—	—	—	—	—	*					
Radiolites angulosus	—	—	—	—	—	—	—	—	—	*					
R. lumbricalis	—	—	—	—	—	—	—	—	—	*					
R. cornupastoris	—	—	—	—	—	—	—	—	—	*					
Sphærulites ponsianus	—	—	—	—	—	—	—	—	—	*					
S. Beaumonti	—	—	—	—	—	—	—	—	—	*					
S. Trigeri	—	—	—	—	—	—	—	—	—	—	*				
S. Sauvagesi	—	—	—	—	—	—	—	—	—	—	*				
S. radiosus	—	—	—	—	—	—	—	—	—	—	*				
Hippurites cornu-vaccinum	—	—	—	—	—	—	—	—	—	—	*				
H. organisans	—	—	—	—	—	—	—	—	—	—	*				
Cyprina coniacensis	—	—	—	—	—	—	—	—	—	—	—	*			
Cardium coniacum	—	—	—	—	—	—	—	—	—	—	—	*			
Lima multicostata	—	—	—	—	—	—	—	—	—	—	—	*			
L. Bauga	—	—	—	—	—	—	—	—	—	—	—	*			
L. coniacensis	—	—	—	—	—	—	—	—	—	—	—	*			
L. Rambaudi	—	—	—	—	—	—	—	—	—	—	—	*			
L. Trigeri	—	—	—	—	—	—	—	—	—	—	—	*	—	*	
Janira docemcostata	—	—	—	—	—	—	—	—	—	—	—	*			
J. quadricostata	—	—	—	—	—	—	—	—	—	—	—	*	*	*	
Pecten Marroti	—	—	—	—	—	—	—	—	—	—	—	*	—	*	
Arca sagittata	—	—	—	—	—	—	—	—	—	—	—	*			
Trigonia longirostris	—	—	—	—	—	—	—	—	—	—	—	*			
Ostrea auricularis	—	—	—	—	—	—	—	—	—	—	—	*			
O. coniacensis	—	—	—	—	—	—	—	—	—	—	—	*			
O. Salignaci	—	—	—	—	—	—	—	—	—	—	—	*			
Sphærulites Coquandi	—	—	—	—	—	—	—	—	—	—	—	*			
Hippurites Sarthacensis	—	—	—	—	—	—	—	—	—	—	—	*			

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Radiolites Mauldei	—	—	—	—	—	—	—	—	—	—	—	*			
Pholadomya Esmarkii	—	—	—	—	—	—	—	—	—	—	—	—	*		
Lyonsia Condamyi	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. inornata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Anatina Nanclasi	—	—	—	—	—	—	—	—	—	—	—	—	*		
Capsa discrepans	—	—	—	—	—	—	—	—	—	—	—	—	*		
Tellina Michelini	—	—	—	—	—	—	—	—	—	—	—	—	*		
Venus uniformis	—	—	—	—	—	—	—	—	—	—	—	—	*		
V. subplana	—	—	—	—	—	—	—	—	—	—	—	—	*		
Opis Truellei	—	—	—	—	—	—	—	—	—	—	—	—	*		
Lucina Michelini	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. campaniensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Mytilus divaricatus	—	—	—	—	—	—	—	—	—	—	—	—	*		
M. Marroti	—	—	—	—	—	—	—	—	—	—	—	—	*		
Lithodomus contortus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Lima maxima	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. Rochebruni	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. Arnaudi	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cardium Rochebruni	—	—	—	—	—	—	—	—	—	—	—	—	*		
Spondylus truncatus	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. spinosus	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. hippuritum ?	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. carentonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. globulosus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Janira Truellei	—	—	—	—	—	—	—	—	—	—	—	—	*		
J. striatocostata	—	—	—	—	—	—	—	—	—	—	—	—	*		
Pecten Dujardini	—	—	—	—	—	—	—	—	—	—	—	—	*	*	
Trigonia limbata	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. disparilis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Arca santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Inoceramus chamæformis	—	—	—	—	—	—	—	—	—	—	—	—	*		
I. labiatus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Ostrea turoniensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
O. proboscidea	—	—	—	—	—	—	—	—	—	—	—	—	*		
O. spinosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
O. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
O. talmontiana	—	—	—	—	—	—	—	—	—	—	—	—	*		
Hippurites Arnaudi	—	—	—	—	—	—	—	—	—	—	—	—	*		
Clavagella cretacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Gastrochæna royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Pholadomya elliptica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Moulinsii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Anatina royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Thracia Baylei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Capsa Arnaudi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Tellina circinalis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. gibbosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. rotundata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Pinna Moulinsii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. restituta	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Mytilus solutus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
M. Moulinsii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
M. Dufrenoyi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
M. reticulatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Lithodomus cretaceus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. intermedius	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. obtusus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Myoconcha supracretacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Avicula carentonensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
A. perigordina	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
A. cœrulescens	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
A. pectiniformis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
A. approximata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Perna royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Beaumonti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Inoceramus impressus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
I. Goldfussi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
I. regularis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
I. Lamarckii	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
I. truncatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Venus subplana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. Archiaci	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Astarte difficilis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Lucina Harlei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Crassatella Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Corbis Salignaci	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. ? striato-costata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cyprina Geneti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Edgardi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. elongata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Plicatula malberchiana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. aspera	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cardium Raulini	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. bimarginatum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. Faujassi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Spondylus royanus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
S. Dutemplei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Chama angulosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. spondyloides	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Lima Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. Baylei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. ficoides	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. difficilis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. inornata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. dissimilis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. tumida	—	—	—	—	—	—	—	—	—	—	—	—	—	*	

	ENGLAND (chiefly Isle of Wight).							FRANCE (South-west).							
	Lower Greensand.	Farringdon Gravel.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Lima truncata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. Paqueroni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Arca cretacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
A. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Trigonia inornata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. echinata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Pecten barbesillensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. medioplicatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. royanus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Nilssoni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. multicostatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Reglevi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Espaillaci	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. recurrens	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. girondinus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Ostrea pyrenaica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. canaliculata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. subinflata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. aviculoides	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. Boucheroni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. larva	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. lunata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. Matheroni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. cornu-arietis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. Overwegi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
O. laciniata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Anomia excentrica	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Radiolites fissicostatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. royanus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. acuticostatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. crateriformis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
R. Bournoni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	*
Sphærulites alatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
S. Sæmanni	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
S. Hœninghausi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Lithodomus hippuritum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Ostrea Lameraciana	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Radiolites ingens	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
R. Jouanneti	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Sphærulites Toucasi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
S. cylindraceus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Hippurites radiosus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
H. Lamarckii	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Gasteropoda.															
Actæon affinis	*														
A. Albensis	*														
A. marginatus	*														
Cerithium attenuatum	*														
C. clementinum	*														
C. Lallierianum	*														
C. neocomiense	*														
C. Phillipsi	*														
C. turriculatum	*														
Dentalium cylindricum	*														
Emarginula neocomiensis	*														
Eulima melanoides	*														
Littorina conica	*														
L. rotundata	*														
Natica cornueliana	*														
N. gaultina	*	—	—	—	*										
N. lævigata	*														
Pterocera bicarinata	*														
P. Fittoni	*														
P. moreausiana	*														
Rostellaria glabra	*														
R. robinaldina	*														
Turritella dupiniana	*														
Natica nodosa	—	*													
Solarium conoideum	—	—	—	*											
S. ornatum	—	—	—	*	*										
Avellana cassis	—	—	—	—	*										
Pyrula Smithii	—	—	—	—	*										
Pleurotomaria perspectiva	—	—	—	—	—	*									
Solarium dentatum	—	—	—	—	—	—	*								
Scalaria Alphonsii	—	—	—	—	—	—	—	—	*						
Globiconcha rotundata	—	—	—	—	—	—	—	—	*						
G. ponderosa	—	—	—	—	—	—	—	—	*						
Natica succinoides	—	—	—	—	—	—	—	—	*						
N. difficilis	—	—	—	—	—	—	—	—	*						
Acteonella lævis	—	—	—	—	—	—	—	—	*						
Actæon elongatus	—	—	—	—	—	—	—	—	*						
Chemnitzia Aeolis	—	—	—	—	—	—	—	—	*						
Nerinea Salignaci	—	—	—	—	—	—	—	—	*	—	—	—	—	*	
N. bisulcata	—	—	—	—	—	—	—	—	*						
N. regularis	—	—	—	—	—	—	—	—	*						
N. Fleuriausi	—	—	—	—	—	—	—	—	*						
N. aunisiana	—	—	—	—	—	—	—	—	*						
N. Bauga	—	—	—	—	—	—	—	—	*						
N. monilifera	—	—	—	—	—	—	—	—	*						
N. Rochebruni	—	—	—	—	—	—	—	—	*						
Rotella Michoni	—	—	—	—	—	—	—	—	*						
Turbo Nanclasi	—	—	—	—	—	—	—	—	*						
Pleurotomaria Boreaui	—	—	—	—	—	—	—	—	*						
Varigera carentonensis	—	—	—	—	—	—	—	—	*						
Pterodonta elongata	—	—	—	—	—	—	—	—	*						
P. inflata	—	—	—	—	—	—	—	—	*						
Cerithium reflexilabrum	—	—	—	—	—	—	—	—	*						
Stomatia aspera	—	—	—	—	—	—	—	—	*						

	ENGLAND (chiefly Isle of Wight).							FRANCE (South-west).							
	Lower Greensand.	Farringdon Gravel.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Strombus inornatus	—	—	—	—	—	—	—	—	*						
S. incertus	—	—	—	—	—	—	—	—	*						
Pterocera Rochebruni	—	—	—	—	—	—	—	—	*						
P. polycera	—	—	—	—	—	—	—	—	*						
Dentalium deforme	—	—	—	—	—	—	—	—	*						
Natica carentonensis	—	—	—	—	—	—	—	—	—	*					
Pleurotomaria Gallieni	—	—	—	—	—	—	—	—	—	*					
P. Rochebruni	—	—	—	—	—	—	—	—	—	*					
Pterodonta intermedia	—	—	—	—	—	—	—	—	—	*					
Cerithium Toucasi	—	—	—	—	—	—	—	—	—	*					
Nerinea subæqualis	—	—	—	—	—	—	—	—	—	*					
N. pauperata	—	—	—	—	—	—	—	—	—	—	*				
N. requieni	—	—	—	—	—	—	—	—	—	—	*				
N. uchauxiana	—	—	—	—	—	—	—	—	—	—	*				
Natica Martinii	—	—	—	—	—	—	—	—	—	—	*				
Cerithium ponsianum	—	—	—	—	—	—	—	—	—	—	*				
Turritella coniacensis	—	—	—	—	—	—	—	—	—	—	*				
Acteonella crassa	—	—	—	—		—	—	—	—	—	—	*			
Phasianella Rochebruni	—	—	—	—	—	—	—	—	—	—	—	*			
P. coniacensis	—	—	—	—	—	—	—	—	—	—	—	*			
Eulima bulimoides	—	—	—	—	—	—	—	—	—	—	—	—	*		
Acteonella involuta	—	—	—	—	—	—	—	—	—	—	—	—	*		
Turritella Bauga	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. coniacensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. umbilicata	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. Guilhoti	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. Vignyi	—	—	—	—	—	—	—	—	—	—	—	—	*		
Scalaria carentonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. Boucheroni	—	—	—	—	—	—	—	—	—	—	—	—	*		
Nerinea Arnaudi	—	—	—	—	—	—	—	—	—	—	—	—	*		
N. analoga	—	—	—	—	—	—	—	—	—	—	—	—	*		
Bulla santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Globiconcha intermedia	—	—	—	—	—	—	—	—	—	—	—	—	*		
Turbo Rochebruni	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. nodosocostatus	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. coniacensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
Delphinula scalaris	—	—	—	—	—	—	—	—	—	—	—	—	*		
Pleurotomaria Raulini	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. Arnaudi	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. coniacensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. santonensis	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. secans	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. Fleuriausi	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. distincta	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. turbinoides	—	—	—	—	—	—	—	—	—	—	—	—	*		
Conus tuberculatus	—	—	—	—	—	—	—	—	—	—	—	—	*		
Pterodonta obesa	—	—	—	—	—	—	—	—	—	—	—	—	*		
Turritella sinistrorsa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. Salignaci	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Nerinea Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
N. mumia	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Globiconcha Fleuriausi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
G. Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
G. truncata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Avellana royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Neritopsis lævigata	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Natica royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
N. rugosa	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Phasianella supracretacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Delphinula turbinoides	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
D. cretacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Turbo Fajoli	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. royanus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Trochus Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. girondinus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
T. difficilis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Phorus canaliculatus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Pleurotomaria Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. royana	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. Espaillaci	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Emarginula gigantea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cypræa ovula	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Rostellaria carentonensis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Pterocera supracretacea	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Fusus royanus	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. Marroti	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. Fleuriausi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. Nereis	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. Harlei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. Espaillaci	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. Nanclasi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. Baylei	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Voluta Lahayesi	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cerithium petrocoriense	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. royanum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Infundibulum cretaceum	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Cephalopoda.															
Ammonites Carteroni	*														
A. consobrinus	*														
A. cornuelianus	*														
A. Deshayesii	*														
A. furcatus	*														
A. Hambrovii	*														
A. Leopoldinus	*														
A. Martinii	*														

	England (chiefly Isle of Wight).							France (South-west).							
	Lower Greensand.	Farringdon Gravels.	Gault.	Upper Greensand.	Chloritic Marl.	Grey Chalk and Marl.	Chalk.	Gardonien.	Carentonien.	Angoumien.	Provencien.	Coniacien.	Santonien.	Campanien.	Dordonien.
Ancyloceras gigas . .	•														
A. matheronianus .	•														
Crioceras Bowerbankii	•														
Nautilus neocomiensis	•														
N. pseudo-elegans . .	•														
N. radiatus . . .	•	—	—	•											
N. Saxbii . . .	•	—	—	—	—	•									
N. lævigatus . .	—	•	—	—	•										
Ammonites rostratus .	—	—	—	•	—	•									
A. selliguinus . .	—	—	—	•											
Hamites armatus . .	—	—	—	•											
Nautilus Fittoni . .	—	—	—	•											
N. undulatus . . .	—	—	—	•											
Ammonites curvatus .	—	—	—	—	•										
A. Coupei . . .	—	—	—	—	•	—	•								
A. mamillaris . .	—	—	—	—	•										
A. rhothomagensis. .	—	—	—	—	•	•									
A. splendens . .	—	—	—	—	•										
A. tuberculatus . .	—	—	—	—	•										
A. varians . . .	—	—	—	—	•	•	•								
A. vectensis . . .	—	—	—	—	•										
Baculites sp. . .	—	—	—	—	•										
Nautilus expansus. .	—	—	—	—	•	—	•								
N. largilliertianus .	—	—	—	—	•	—	•								
Turrilites Bergeri . .	—	—	—	—	•										
T. gravesianus . .	—	—	—	—	•										
T. puzosianus, var. .	—	—	—	—	•										
T. tuberculatus . .	—	—	—	—	•	•	•								
Belemnites ultimus .	—	—	—	—	•	—	•								
Ammonites feraudianus	—	—	—	—	—	•									
A. laticlavius . .	—	—	—	—	—	•	•								
A. leptonema . . .	—	—	—	—	—	•	•								
A. octosulcatus . .	—	—	—	—	—	•									
A. rensauxianus . .	—	—	—	—	—	•									
A. renevieri . .	—	—	—	—	—	•									
A. velledæ . . .	—	—	—	—	—	•									
Nautilus deslongchampsianus . .	—	—	—	—	—	•	•								
Scaphites striatus . .	—	—	—	—	—	•									
Turrilites bifrons? .	—	—	—	—	—	•									
T. costatus . . .	—	—	—	—	—	•	•								
T. Westii . . .	—	—	—	—	—	•									
Ammonites cinctus .	—	—	—	—	—	—	•								
A. falcatus . . .	—	—	—	—	—	—	•								
A. peramplus . .	—	—	—	—	—	—	•	—	—	•					
Nautilus elegans . .	—	—	—	—	—	—	•								
N. triangularis . .	—	—	—	—	—	—	—	—	•						
N. Fleuriausi . . .	—	—	—	—	—	—	—	—	•						
Ammonites Fleuriausi	—	—	—	—	—	—	—	—	•						
A. navicularis . .	—	—	—	—	—	—	—	—	•						
A. Mantelli . . .	—	—	—	—	—	—	—	—	•						
A. Wolgarii . . .	—	—	—	—	—	—	—	—	•						
A. Carolinus . . .	—	—	—	—	—	—	—	—	•						
A. Vielbancii . .	—	—	—	—	—	—	—	—	•						
A. engolismensis . .	—	—	—	—	—	—	—	—	•						
A. caprinarum . .	—	—	—	—	—	—	—	—	•						
Nautilus sublævigatus	—	—	—	—	—	—	—	—	—	•					
N. Sowerbyi . . .	—	—	—	—	—	—	—	—	—	•					
Ammonites Alphonsii	—	—	—	—	—	—	—	—	—	•					
A. Boucheroni . .	—	—	—	—	—	—	—	—	—	•					
A. Gealini . . .	—	—	—	—	—	—	—	—	—	•					
A. Requieni . .	—	—	—	—	—	—	—	—	—	•					
A. Rochebruni . .	—	—	—	—	—	—	—	—	—	•					
A. papalis . . .	—	—	—	—	—	—	—	—	—	•					
A. ganiveti . . .	—	—	—	—	—	—	—	—	—	•					
A. Trigeri . . .	—	—	—	—	—	—	—	—	—	•					
A. Deveriæ . . .	—	—	—	—	—	—	—	—	—	•					
A. Nouleti . . .	—	—	—	—	—	—	—	—	—	—	—	•			
A. Bourgeoisi . . .	—	—	—	—	—	—	—	—	—	—	—	—	•		
A. Orbignyi . . .	—	—	—	—	—	—	—	—	—	—	—	—	•		
A. polyopsis . . .	—	—	—	—	—	—	—	—	—	—	—	—	•		
A. santonensis . .	—	—	—	—	—	—	—	—	—	—	—	—	•		
A. coniacensis .	—	—	—	—	—	—	—	—	—	—	—	—	•		
Baculites incurvatus .	—	—	—	—	—	—	—	—	—	—	—	—	•		
Scaphites constrictus .	—	—	—	—	—	—	—	—	—	—	—	—	•		
Nautilus De Kayi .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	•
Ammonites gollevillensis	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
A. Marroti . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
A. petrocoriense . .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Turrilites Archaici .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
T. Heberti . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Baculites Faujasi .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
B. anceps . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Scaphites Nanclasi .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
S. Baylei	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
S. Heberti . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Vertebrata.															
Pisces.															
Hybodus basanus . .	•														
Corax elongatus . .	—	—	—	—	—	—	—	—	•						
C. parallelus . . .	—	—	—	—	—	—	—	—	•						
C. trapezoidalis . .	—	—	—	—	—	—	—	—	•						
Pycnodus Rochebruni.	—	—	—	—	—	—	—	—	•						
P. distans	—	—	—	—	—	—	—	—	•						
Gyrodus carentonensis	—	—	—	—	—	—	—	—	•						
Lamna Trigeri . .	—	—	—	—	—	—	—	—	•						
Otodus Michoni . .	—	—	—	—	—	—	—	—	•						
Orthodon Condamyi .	—	—	—	—	—	—	—	—	—	—	—	•			
Pycnodus coniacensis.	—	—	—	—	—	—	—	—	—	—	—	•			
Oxyrhina Arnaudi .	—	—	—	—	—	—	—	—	—	—	—	—	•		
Lamna subulata . .	—	—	—	—	—	—	—	—	—	—	—	—	•		
Corax Boreaui . .	—	—	—	—	—	—	—	—	—	—	—	—	•		
Enchodus lewesiensis	—	—	—	—	—	—	—	—	—	—	—	—	•		
Pycnodus parallelus .	—	—	—	—	—	—	—	—	—	—	—	—	•		
Otodus Marroti . .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Lamna petrocoriense .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Pycnodus occidentalis	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Ptychodus Pauli . .	—	—	—	—	—	—	—	—	—	—	—	—	—	•	
Reptilia.															
Plesiosaurus sp. . .	•														
Undetermined species	—	—	—	—	—	—	—	•	•						
Mosasaurus carentonensis	—	—	—	—	—	—	—	—	—	—	—	•			

The above table, lengthy though it be, is not intended to be complete; but it serves to illustrate the extraordinary distribution of the fossils; a distribution which reveals traces only of what was the actual arrangement of the fauna then living. The record is manifestly very fragmentary and disconnected. The strata also present the same character. Thus, as we have indicated, Ireland has a less complete succession of beds than England, and France possesses many strata which have not been discovered in England; and if we had space, we could have shown that strata, apparently intermediate in age between some of those in France, are to be detected in other countries. But these details, and many others as much deserving of insertion as those which have been given, must be omitted. Thus we should much like to have pointed out the analogy between the deposit now forming at the bottom of the Atlantic (about which so much is now being learnt by means of deep-sea dredging), and those of the cretaceous epoch; such as the chalky ooze permeated with a profusion of living organisms, and the zones of siliceous material abounding in grains of green silicates, which grains are believed to be the casts of interiors of minute shells. The occurrence of blocks of stone and patches of gravel in the chalk, which is usually so free from non-calcareous particles, has been attributed by some to the agency of sea weeds and trees, borne along by currents from the sea margin; but some authors, as Sir C. Lyell, consider that the absence of any carbonaceous matter associated with them, and the occasionally large size of the fragments, supports the idea that floating ice may have had a share in their distribution and transportal. Then again, there are the remarkable group of strata, which have been so ably described by Professor Whitney and his coadjutors in the survey of California. They have shown that the beds of this age in that State are highly metamorphosed, and enclose thick layers of coal. We cannot enter into these matters, and are therefore compelled to refer the reader to the works cited at the end of this article. He would do well if he were also to consult D'Archiac's 'Histoire des Progrès de la Géologie,' vols. 4 and 5; the 'Bulletins,' published annually by the Geological Society of France; the 'Revue de Géologie,' issued every year by Delesse, Laugel, and Lapparent; the numerous monographs in the magnificent 'Paléontologie Française;' in the volumes of the 'Palæontographical Society of London;' and in the 'Palæontographica' of Dunker and Meyer; numerous papers in the 'Sitzungsberichte' of the Scientific Academy at Vienna; the 'Jahrbuch' of the Imperial Geological Society of Austria; the 'Zeitschrift' of the German Geological Society; the 'Comptes Rendus' of the Academy at Paris; the 'Quarterly Journal' of the Geological Society of London; and the publications of many other Societies. There are also many papers scattered through a host of periodicals, such as the 'Geological Magazine,' the 'American Journal of Science and Art,' Leonhard and Geinitz's 'Jahrbuch für Mineralogie, &c.,' the 'Geologist,' &c., &c. Much may be gleaned from special works like Reynes' 'Études sur le synchronisme et la délinéation des terrains cretacées du sud-est de la France, 1861;' Gras, 'Déscription géologique du département de Vaucluse, 1862;' the 'Palæontologica Indica;' Whitney, 'Geological Survey of California;' Coquand, 'Monographie paléontologique de l'étage aptien de l'Espagne, 1866,' &c., &c. Those who do not care to sift the great mass of material in the volumes above mentioned, should consult the manuals by Dana, Lyell, Jukes, Phillips, Naumann, and others.

(Bristow, Etheridge, De la Harpe and Salter, *Memoir of the Geological Survey of Great Britain* (on sheet 10); Coquand, *Bulletin de la Société Géologique de France*, Second Series, vol. 16, p. 945, *et seq.*; Tate, R., *Quart. Journ. Geol. Soc.*, vol. xxi. p. 15; Judd, *Quart. Journ. Geol. Soc.*, vol. xxiii. p. 227; xxiv. p. 218. Rev. T. Wiltshire, *Quart. Journ. Geol. Soc.*, xxv. p. 285.)

CHARLOCK [SINAPIS, E. C. S.]

CHAUNA. A genus of birds whose systematic position has long been in doubt, and the members of which present several remarkable structural features. In the E. C. the genus is described under PALAMEDEA, vol. iv. col. 163, and the species are there assigned to two genera, viz., *Chauna* and *Palamedea*. It is now generally admitted that all the species so assigned belong to one genus, for which the name *Chauna* is retained. Under CARIAMA, E. C. vol. i. col. 779, a bird is described under the appellation of *Palamedea cristata*, but this has no relation to the genus under notice. In the present state of our knowledge two species are assigned to the genus, viz., *C. chavaria* and *C. derbiana*. The former inhabits Southern Brazil and Paraguay, the latter New Granada and Trinidad; but it has also been said to occur in Guatemala, although there is no satisfactory evidence in support of the statement. *C. chavaria* is the larger and lighter coloured species, and has an ill-defined black ring low down on the neck. *C. derbiana* has the neck wholly black, and the throat white.

In 1863 some specimens of *Chauna* were sent to the Zoological Society of London by Mr. Greey, who furnished the following notes on its habits: "It utters three peculiar sounds—a trumpet-like scream; a gobbling, turkey-like noise, accompanied by a peculiar bowing of the head; and a hollow, rumbling noise in its inside when enraged. Another peculiarity of the species is the cellular membrane between the skin and the flesh being capable of distension, thus accounting, doubtless, for the rumbling sound emanating from its inside. It has two spurs on each wing; when attacked, it throws back its head, brings forward its wings, and stands on the principle of 'defence, not defiance.' It will kill snakes, and, though very wild in its natural element, becomes very docile when associated with other fowl."

The specimens above alluded to were named *C. chavaria* on their arrival in this country, but they were soon after described as a new species by Dr. Sclater under the name of *C. nigricollis*; and still more recently he has discovered that the birds really belong to *C. derbiana*. In 1864 Dr. Crisp published some remarks on the visceral anatomy of "*Chauna chavaria*," and Mr. Parker has written a valuable memoir on the anatomical structure of "*Palamedea chavaria*." At first sight it might be supposed that the observations of Messrs. Sclater, Crisp, and Parker had reference to three different species, but we believe they are based on the same species, and even on the same individuals. The true specific name appears to be *Chauna derbiana*.

Dr. Crisp verified the statement that air is present beneath the skin, and further ascertained that nearly every bone is permeated with air. Special arrangements have been made to render the bird as light as possible—a feature which seems to be related to its habit of walking over the leaves of the aquatic plants which flourish in its marshy home. Dr. Crisp also draws particular attention to certain other peculiarities: "The tongue is fleshy, thick, and rather pointed. The trachea is large above, and small below; but the greater part of the tube is uniform in size, and the rings firm and unyielding; the rings number 129. Two pairs of muscles are present at the lower part—the *sterno-tracheales* and *broncho-tracheales*: these are of large size. The eyes are large; irides of a light yellow colour. The lungs, heart, kidneys, thyroids, spleen, pancreas, generative organs, and renal bodies present no remarkable deviation from the ordinary types, except that the generative organs and renal bodies are of a deep orange colour. The lobes of the liver (in both specimens) are connected by a very small, narrow isthmus, much smaller than I have seen it in any other bird of the same size. But the intestinal tube of this bird offers some of the most curious anomalies. The œsophagus is of uniform size, and of moderate capacity; the proventriculus thick and capacious; the glands large and flask-shaped; the gizzard thin; its parietes of nearly the same thickness in every part; the calibre of the small intestines moderate, and that of the rectum very large. The mucous lining of this gut forms forty-two transverse folds, so as to extend greatly the absorbing surface. The subjoined is the length of the canal:—

Œsophagus	12 inches.
Gizzard	2½ "
Small intestines	50 "
Appendices, three	6 "
Large intestine	13 "
	83½

"The intestinal tube holds 14 ozs. 3 drachms of water. The appendices, although short, are very capacious, and, like the large intestine, are furnished with transverse folds of the mucous membrane, but more faintly marked. The important peculiarities of this bird are the great lightness of the skeleton, the presence of air under the skin, the great length of the rectum, and the extent of the mucous folds, the large calibre of the appendices, and the very slight connection between the hepatic lobes."

Most authorities have placed *Chauna* amongst the *Rallidæ*; but Mr. Parker considers this to be unquestionably erroneous, and that its proper position is amongst the *Anatinæ*—an opinion which has received considerable support amongst ornithologists. His reason for this opinion may be partly gathered from the following extract quoted from his paper in the 'Proceedings of the Zoological Society, 1863,' p. 513, "A very large number of the genera of birds partake of a structure and nature which may very appropriately be called passerine; and another very large group, both of genera and families, may also be called pluvialine,—the common, grey, and dotterel plovers being typical of these groups, which run up through the sandpipers and curlews to the ibises in one direction, through the lapwings and stone plover to the bustards and cranes in another, and through *Chionis* and the Pratincole to the petrels and the gulls. Still this does not exhaust the pluvialine birds; for the geese and their allies are allied on one hand to the ibises through the flamingo, and on the other to the cranes, although the proper connecting link in this case is doubtful, *Palamedea* lying obliquely, not directly between them. The megapodes, hemipodes, sand grouse, and tinamous, also, have no little proportion of the plover in their nature. The jacanas (*Parra*) are essentially plovers, although they have something of the rail in them, especially in the skulls; and they are united to the typical forms by other spur-winged plovers (*Pluvianus spinosus*, Gould). Now, looking at the anatine birds as a great division of specialised forms parallel with, and intimately related to, the pluvialine birds, we begin to see how they can be related to the mixed '*Gallinaceæ*,' which have so much of the plover in their essence. But we had much, at starting, in common between the typical and pure fowls and the duck and goose tribe; add to this the fact that the mound-makers and curassows come much nearer to the *Anatinæ*, and then suppose an anatine bird in which the horny denticles are feeble but abundant, and the jaws compressed, stout, and trenchant, the same bird having the occipital region in harmony, not with the geese, but with the fowls—put all these things together, and we shall be supposing what really exists in the *Palamedea*. Then we can calmly look at the fact that those geese which have spurs in their wings, like those of the *Palamedea* (viz., *Chenalopex* and *Plectropterus*) have their legs longer, more grallatorial, and better under them than the typical form, and that the spur-winged goose (*Plectropterus*) has a pelvis exactly intermediate between that of a typical goose and that of a *Palamedea*. It is worth while to notice the thick down that covers the *Palamedea*, the height of the bare tract on the tibia, and the reticulated tarsi, like those of the goose, and not like those of the cranes and rails, which have them scutellate in front. Whilst removing the viscera, I saw that the trachea and inferior larynx were truly anserine, for there are no inferior laryngeal muscles, the contractors of the trachea ending one-third of an inch above the bifurcation, and only a delicate fan-shaped fascia going to the half rings. Moreover, the trachea itself, from being flat and cartilaginous, becomes round and then compressed and osseous an inch above the bronchi, so that it cannot be mistaken for the trachea of any other than an anatine bird. There is nothing whatever in the digestive organs, which are extremely voluminous, to separate the bird from the goose; yet the gizzard is not so strong as in the types, and the *cæca coli* are shorter and wider. I have at present only hinted at the osteology of the *Palamedea*. It diverges from the goose in all this part of its composition just as much as it converges towards the curassow and the *Talegalla*; but it is not only more galline than the true geese (we have already seen that both geese and fowls have much in common), it is also plainly more *lacertine*. It will require a goodly memoir to do it justice, but in this short notice I must mention one or two things. Its large soft tongue, which has not the papillæ bony, has in it the cerato-hyals, ossified from separate points, as in the goose and hen, much nearer the former than the latter; but the free thyro-hyals are flattened from above downwards, and cannot be mistaken for those of any other but an anserine or anatine bird. All the skull and face, except at its two ends, conforms to the lamelli-rostral type, Point by point, process by process, lamina for lamina, all else is truly and distinctly that which belongs to the Sifter and to no other bird. It may be said, indeed, that this bird is not a Sifter; it is, however, a browser and grazer; and being of Lincolnshire descent, and familiar with the fens, I am well acquainted with the grazing habits of the typical goose. There is a little of the crane in the sternum; but, on the whole, the skeleton may be said to belong to a very *lacertian* goose." He goes on to show that the spur-winged birds are on the same ornithic plane as *Chauna*, the only exception known to him being the Syrian blackbird (*Merula dactyloptera*). He has some remarks on the number of vertebræ between the heads of the thigh bones and the true caudal series. The genus is of especial interest, since few, if any, living birds approach nearer to the lizard than it does, and since there are many parts of its structure which indicate that it is the nearest living relative of the wonderful *Archæopteryx* of oolitic times.

CHEIROPTERA [E. C. vol. i. cols. 961—976]. Bats represent a curiously modified order of vertebrates adapted for flight, and are as exceptional in this respect amongst mammals as were the pterodactyles of old amongst reptiles. Of the four principal types of organs of flight, viz., those of the bat, the birds generally, the *Archæopteryx*, and the pterodactyles, the fore limb of the bat presents the extreme degree of modification in one direction, that of living birds presenting the opposite extreme, while those of the *Archæopteryx* and pterodactyles occupy a middle place. Thus, looked at as a whole, it is observable that the more distal bones of the fore limb, from the carpus outwards, form but a small proportion of the total length in living and extinct birds, whereas in the *Archæopteryx* and bats they are usually longer than the remainder of the limb. But when the several parts are compared, the following relationships are to be noticed. In the bat's fore limb the scapula is short and stout, the humerus is much longer and of more slender proportions than the scapula; the forearm is almost entirely composed of the radius, a rudiment only of the ulna being welded to its proximal end; the carpus or wrist consists of six bones; the metacarpus is formed of five separate and highly elongated metacarpals; and the phalanges are also of slender proportions. The pterodactyle has a somewhat more slenderly-proportioned scapula than the bat; the humerus is short, stout, and straight; the ulna and radius are also short and stout, nearly equal in length, distinct from one another, but closely approximated; there are five bones in the carpus, four in the metacarpus, which are separate, of nearly equal length, but the metacarpal of the fourth finger is much shorter than the others; the phalange of the first three fingers are small, slender, and terminated by claws, while those of the fourth or fifth are relatively of enormous size and length. In birds the humerus is intermediate in proportions between those of the pterodactyle and bat; the ulna and radius are distinct, not amalgamated together, the ends only are in apposition, while the bodies are spaced apart owing to their curvature; the carpus consists of two bones only; the metacarpus consists of two, and sometimes three bones, of which one is much smaller than the others. In the *Archæopteryx* there are four distinct metacarpal bones, of which two are much larger than the others. Although much might be said respecting the anatomy and physiology of the *Cheiroptera*, and numerous diagnoses might be given of genera not noticed in E. C., we refrain from entering into details, as they would carry us beyond our limits. We may observe, however, that the insect hunters are readily recognised by their exceedingly large ears, interfemoral membranes, and more or less developed appendages to the nose; the index finger has no nail; and the stomach is short or globular. In those species which live more or less upon fruits the ears are of moderate size, the foliaceous developments of the nose are moderate or rudimentary, the index finger generally has a nail, and the stomach is elongated. There are also certain genera which live upon the blood of animals; they agree with the last-mentioned group in the moderate size of the ears and nose appendages, and with the first-mentioned group in having an index digital claw; but differ from both in having an immense cardiac cæcum to the stomach. Thus in one specimen of *Desmodus rufus* the body measured from 3·2 inches from the snout to the end of the tail; the intestines, from the pylorus to the anus, was 11 inches; and the cæcum, which opened into the stomach near the pylorus, was 6·5 inches in length.

Passing by these branches of the subject, we propose to dwell on some of the habits of these creatures, partly because the facts recorded in E. C. are founded upon captive individuals only, and partly because details of this kind are rarely to be met with. In the 'Proceedings of the Zoological Society' for 1865 are numerous extracts from the diary of Mr. Osburn, relative to the habits of the bats of Jamaica, from which we have derived most of the following notes and quotations. The quotations are necessarily lengthy, as in anecdotes much depends upon the manner in which they are related.

Nyctinomus nasutus. This species abounds in ruined and deserted houses, and even frequents the unoccupied portions of those which are inhabited. As soon as the sun dips below the horizon these creatures issue from their roosting place, of which Mr. Osburn gives the following description, as seen at Rowington Park, Vere. "Vast numbers of these little bats inhabit the shingled roof of this house. It is an unusually favourable place for observing them. The rooms are ceiled. A store-room without ceiling communicates directly with the roof, whence a view can be obtained of a large part over the ceiling of the other rooms. A crack in the boarding that crossed a gable let in sufficient light for easy observation, and was besides of great importance to the bats as their principal avenue of communication with the outer world. I often observed them during the day exactly as Goldsmith's line expresses, 'lazy bats in drowsy clusters cling;' for, what seems surprising, notwithstanding the extreme heat of the situation—shingles exposed to the sun (and it was disagreeably hot and confined where I stood, twelve or fifteen feet below), the bats clung in complete clusters. I counted fourteen little heads in a mass about the size of a turnip. But they are not all asleep; now and then a wing is stretched with drowsy enjoyment; and the luxury King James thought too great for subjects and ought to be reserved for kings, is largely indulged in by bats. First one and then another wakes up, and, withdrawing one leg and leaving himself suspended by the other alone, adroitly uses the foot at liberty as a comb, with a rapid effective movement dressing the fur of the under part and head—an action far from ungraceful. The foot is then cleaned quickly with the teeth or tongue, and restored to its first use. Then the other leg does duty. Perhaps the hairs with which the foot is set may aid to this end. I often have seen them do this in confinement; and probably the numerous bat-flies with which they are infested may be the cause of extra dressing. It is impossible to imagine a more perfect or effective comb than the little foot thus used makes; and I would here remark on the extreme sensitiveness of these little animals. I have often been painfully impressed with the amount of suffering some of my experiments were causing, by observing their fretful impatience; a bat, with its wings broken, its bright little eye glazed with coming death, would resent the first touch and hum of a mosquito, and exhaust its dying efforts to escape the annoyance. A little after sundown, and, from the room below, the roof seems alive with movement; there are squeaks and a shuffling scuffle over the boards. From the place of observation before referred to it is too dark to see plainly the bats within, though their little forms may be traced scrambling eagerly up the boards of the gable, till they arrive at the chink, when they become quite plain against the evening sky without, as they go over the edge, their elbows and ears in the action being particularly prominent. From without, or the window below, we can see them shoot off with great rapidity (so that I have heard disputes as to whether they are bats or swallows), and dart after their insect supper with the most intense enjoyment over the neighbouring trees and pastures. I would remark that there is a distinction in the mode of flight of these bats and our *Hirundo pœciloma*. This is, that whilst the arc formed by the tip of the swallow's wing is as much below as above the body, the wings being as far apart when fully raised as when fully depressed, in the bat the wings scarcely rise above the level of the body, and meet apparently below. I do not mean this is universally the case. I do not think the frugivorous bats do it; but it is very apparent in some of the insectivorous bats when going at a great rate; and as I know this species by tracing their course as they shoot from their roosting place, it must be noted as one of the most remarkable for this. Their exit during March was about half-past six o'clock: about eight to nine o'clock they returned. It is then they are so particularly annoying to the inhabitants of even the most carefully kept Jamaica houses. The great majority return to the roof; but one or two vigorous little fellows come into the rooms, and flap about in the most unmeaning way. Nothing is more remarkable than the agility with which a dozen, in the early part of the evening, skimmed and glided by every article of furniture. But now they bang themselves against the ceiling and walls, dash on the table, get up again, when the cat, by jumping, catches them a pat, and they fall on the floor, not much hurt, to judge by their liveliness; for grimalkin, having performed the feat, sits down, her paws tucked under, and gravely watches the hurry of the alarmed bats shuffling over the floor. They disturb the harmony of the evening by becoming the occupants of, and making an escapade beneath, a gentleman's coat-collar, or a great sensation by getting entangled hopelessly in a lady's hair, and bite more furiously than effectively during the process of release. They remain very active all night, scampering and shuffling about their ample quarters. For several nights the noise was so great, I attributed it to rats; but the Doctor assured me there were none—it was these little animals alone; and I found he was right. I do not know at what time they again start for their morning meal, but they return between five and six in the grey of the morning." The anecdote mentioned in Dr. Allen's Introduction to his 'Monograph of the Bats of North America,' appears to refer to this or an allied species. It records how a house in Maryland, which had been uninhabited for several years, came to be purchased by a Portuguese gentleman, who was assured that it was in good habitable condition. The furniture, luggage, all were sent on beforehand, and in the evening the family arrived travel-worn and fatigued. The evening being fine, chairs and seats were laid out on the lawn in order that the party might rest themselves and enjoy the calm summer air. But hardly had they comfortably settled down than crowds of small bats issued from every open window and hole in the house, darkening the air and causing the ladies to fly from their seats for fear of the vampires lodging in their hair. This visitation of bats was quite unexpected, as nothing was seen of them during the visit to the house prior to purchase; but that was made during the winter, when the bats were dormant, whereas the settlement was effected in summer, when the bats were in their highest activity. Every effort was made to exterminate the bats as a nuisance, and, in order to hit upon the readiest method, their habits were watched for several successive evenings. They were seen to issue from holes in the roof in twos and threes as soon as the 'whip-poor-will' commenced his peculiar note, and flew direct to the river for the purpose of drinking. They flew about after insects for a few hours, again retired to their roosting-places during the darkness of night, and again emerged at the call of the 'whip-poor-will' at early dawn. This fact having been ascertained, all but a few apertures opening into a room were plastered up, and the whole force of the establishment planted at the several holes, each member being armed with a stout stick. As the bats escaped through the holes they were struck down. The operation lasted several days, and resulted in the destruction of upwards of ten thousand individuals.

Arctibeus carpolegus. It dwells in large numbers in caves. When the net is brought near one for the purpose of capturing it, the ears vibrate rapidly independently of one another, and the nose leaf is also vibrated as though it were feeling for sound and smell to enable it to detect the nature of the danger. The floors of the caves frequented by it are strewed with the munched ejected skins of the fruit of *Cordia collococca*, as well as fragments of mangos and rose-apple (*Eugenia jambos*). It appears to be somewhat more partial to daylight than most bats, since it usually congregates near the entrance, and is seldom found in the darker recesses. Its habits, however, vary with the district. Thus where limestone abounds it frequents caves, but where the strata consist of shale or other material not favourable for the formation of caves, it clusters in large groups under the fronds of the cocoa-nut palm, and feeds upon the pulp of the young nuts.

Chilonycteris Osburni. Very few notes were made on its habits in the natural state, but a dozen specimens were kept in the house for a few days. During the day they clustered, head downwards, in any dark hole they could find, now and then jumping up with a sibilant chirp. Soon after five o'clock they rouse themselves from torpidity, agitate the tips of their ears with a rapid motion in a backward and downward direction, and in flying the interfemoral membrane is stretched tight by means of the calcanea or heel-bones. One individual had some water spilt on its muzzle and face, which it removed by placing the head under the fore-arm, and adroitly brushing the moist parts with the hind paw, the motions of which were extremely rapid. This done, the paw was cleaned by licking.

Monophyllus Redmanii. This species is remarkably active, and when confined in a box it runs round with a series of rapid jumps like a mouse. When a glass was placed over one in the box, it immediately darted its tongue against the wood, for the purpose, apparently, of ascertaining its nature, and the nose-leaf and ears were in active motion, being directed first in one direction and then in another while endeavouring to discover some place of exit. The tongue is very extensile, and has a remarkable brush-like tip, but what its function is has not been ascertained. Its resemblance to the similar tongue of *Tanagrella ruficollis*, which is used for sucking juicy fruits, suggests the idea that the bat may use its tongue for the same purpose. This is supported by the observations made by Mr. Osburn on the species to which we are about to refer.

Phyllonycteris Poeyi. This species frequents caves in immense numbers, swarming on the walls and roofs like bees. An expedition was made to one cave, and seventeen specimens obtained therefrom, of which the best conditioned were taken home in a gauze-covered box. "They bit fiercely, and not ineffectually, at my fingers, were extremely active, and ran about the box with great agility. One or two managed to get out, when I found they could run on the floor and rise to the wing with the greatest ease. After one or two turns round the room, they hitched themselves, raised the head a little, and moved the nose-leaves and ears alternately, in the eager enquiring way of *Monophyllus Redmanii* and *Arctibeus carpolegus.* All night I was disturbed with their violent efforts to escape. I congratulated myself I had taken the precaution to line the bottom with a good bed of silk cotton, for otherwise the inflammation produced on the wrists by their efforts renders them unfit for preservation. The loud bird-like chirps and squeaks were incessant. Next morning I found them much exhausted and quiet; they no longer bit at my fingers. A female with a young one had it still hanging to her breast; but another young one I had put in hap-hazard from a heap was hitched up to the muslin by itself. I sent for a berry-laden branch of *Cordia collococca*, which I had seen strewn on the floor of the cave, but first took the precaution of letting them drink, lest an abnormal thirst, produced by their exertions or injuries should make them take the juice. They drank eagerly, protruding the tongue—the lip [? tip], hollowed spoon-shape, and the bristles, evidently taking up a great quantity. They would anxiously lick it [? water] off my fingers. When they began to refuse more, and shake their heads at it, I tried the berries; but, to my disappointment, they took little notice of them. A couple of hours afterwards I tried again, when it occurred to me to break the skin, so as to let some of the juice escape. The one I presented it to, after a little persuasion, began to lick the juice: he at last seemed to understand his new position, and licked away in good earnest. The tongue was rapidly protruded and drawn in again, and the juice and softer pulp cleared away with great rapidity. I noticed he was very particular in cleaning out the bit of loose skin of berry, and licked my fingers of the juice spilt on them, carefully clearing out any that had collected under the nail. The sensation was not at all unpleasant, the tongue feeling soft and spongy, with a slight scratching from the bristles. I then got another berry. The bat was hanging from the edge of the box, its ventral surface against the side; and as I held the berry a little off so as to see the action of the tongue, it had, whilst feeding, to bend the neck so as to raise the head a little: this seemed to fatigue it. It, therefore, raised itself on one wrist, and turned round so that its back was against the box's side; but as it did not change the position of the feet, of course the legs crossed, the right foot now being on the left side, and *vice versâ.* In this odd position it seemed perfectly at ease, and went on licking at a fresh berry with great relish. Of course, only its chin was now visible to me. I then began gradually to lower the berry: it stretched first the neck and then the tongue to its full extent. I took it beyond reach and then suddenly brought it close again. It seized it with its teeth savagely, so that the long sharp canines of one side and the blunt molars held the berry, much as a dog will do when he wishes to bring the force of the molars to bear upon a bone. This left room for the tongue still to be protruded; for, from the arrangement of the minute lower incisors in a concave, the molars can be nearly closed, so as to hold an object, and the tongue still have room for protrusion. The little body trembled with the eagerness of his actions. As the pulp and juice he could thus reach became extracted, I expected he would drop it, and was prepared with another berry; but, to my surprise, he brought up the wrists to the muzzle, took the berry between them, gave it two or three energetic bites, and then held the berry off. So I now understood what the unusually long thumbs were for; for they applied themselves dexterously to the berry, held it firmly, and then, as it appeared to me, by a reverse action of the two wrists, the berry was turned round, a fresh hold taken by the teeth, and the same licking process renewed, till the seed in the centre was cleared of the pulp, all but the little bit which served for the last tooth-hold. It was then dropped, and the eager little muzzle raised for more. I supplied another, and soon I had a little heap of seeds with bits of pulp attached, at the bottom of the box, exactly like those I found in the cave. A wounded bat on the floor found some berries out and began to lick them. I next tried the female with a young one, with precisely the same result; only, notwithstanding her eagerness for food and evidently hungry state, it was affecting to see how constantly she stopped carefully to lick the little one at her breast, lest any spilt juice should soil it. When holding the berries in the wrists their appearance reminded me much of monkeys. They now became very lively, evidently much refreshed by the meal, and began to snap at my fingers. I covered them up in darkness, which they seemed to want. On my return I found the young bat which I had put in as an orphan had been taken by the other female, and was evidently sucking vigorously. It can hardly have happened that out of such a number I could have chosen mother and offspring by chance. Perhaps the old bat, feeling the pressure of milk, in this way sought relief. The young were quite naked and blind, and about two inches long, but clung with great tenacity. From a portion of umbilical cord still attached to one mother, I conclude one had been born only quite recently. I then took them and put them among the twigs of *Cordia*. They climbed about it, heads downwards, with the greatest ease. The length of the legs and toes, their muscularity, and the absence of any interfemoral or tail, were all obvious advantages where this habit was constant, especially the power it gave them of turning as on a pivot, but without moving the feet. They twisted, within certain limits, like a body suspended by a string. They would thus follow a berry I moved; but they would not pluck any of the berries for themselves, seeming only anxious to get into a dark place. This I attribute to the unnatural hour of feeding. On placing them in the box, I found, after a short time, both mothers had crossed the legs in the attitude before-mentioned, to avoid pressing the young against the side. I put them out of doors on a tree at some distance from the house. One attempted to return, doubtless to escape the light. It lit on a plastered wall, and notwithstanding the encumbrance of the suckling, ran up the wall backwards by the legs with great rapidity (raising the body with the wrists so as not to rub the young), till it gained the shelter of the eaves, whence I hope it made a complete escape, for I left Harmony Hall that afternoon. From these observations I would infer that we have an explanation of the much greater muscularity of the frugivorous bats than the insectivorous; and, further, of the use of the wrists in the bat."

Bats, however, do not confine their food to insects and fruits, for the *Pteropus edulis* of India has been seen to skim the surface of water, snatch the fish, which ascend to the surface, with its feet, and carry them to a neighbouring tree, where it may devour its prey at leisure.

Those who seek for descriptions of genera and species, not their habits, are referred to the series of papers by Mr. Tomes in many of the recent volumes of the 'Proceedings of the Zoological Society,' to the synopses of genera in the 'Proceedings' of the same Society for 1866, and in the 'Annals of Natural History,' second series, vol. xvii., and to the articles by Professor Peters in the 'Monatsberichte' of the Scientific Academy of Berlin for several years past.

(Allen, *Monograph of the Bats of North America*, in *Smithsonian Miscellaneous Collections*, vol. vii.; Shortt, *Proceedings of the Zoological Society for* 1863; Osburn, *Proceedings of the Zoological Society for* 1865, p. 61.)

COAL FORMATION [E. C. vol. ii. cols. 10—28]. In the article here referred to this term is intended to apply more particularly to the beds now usually called coal measures; while the other members of the Carboniferous Formation have separate notices under Mountain Limestone and Millstone Grit. As these groups of strata are intimately connected together, we prefer to treat them collectively under the term Carboniferous System in E. C. S.

CŒLENTERATA. [Actinozoa, E.C.S.]

CŒREBA. A genus of birds founded by Vieillot in 1807, and at present comprising 6 well defined species, according to Mr. Cassin, who made a careful examination of this and allied genera in 1864 ('Proc. Acad. Nat. Sci. Philad.,' p. 265, 1864); but he particularises a few specimens which present such variations from the species to which they have been assigned as may warrant their being raised to specific rank. Linnæus was acquainted with one or two species, which he described under the generic term *Certhia;* but most ornithologists now believe that *Cœreba* is widely separated from the Creeper family. The creepers generally have a dun-coloured plumage, in which brown, black, white, and various sombre tints prevail, whereas the *Cœrebidæ* are generally remarkable for their bright green, blue, and yellowish colouring. The family comprises 8 genera, viz., *Cœreba*, *Chlorophanes* (1 species), *Dacnis* (14 species), *Certhiola* (12 species), *Conirostrum* (4 species), *Spodiornis* (1 species), *Diglossa* (13 species), and *Diglossopis* (1 species). All the forms are restricted to the central parts of America.

COPPER. For what has already been said respecting this metal and its ores, the reader is referred to Copper in the Nat. Hist. and Arts and Sci. Divs. In the present account many of the facts stated in those articles will be rementioned. This repetition is unavoidable, as the chief interest of the facts arises from the application that is made of them to illustrate the properties of copper and its compounds.

Copper rivals iron in the universality of its distribution, in the multitude of its native compounds, and in its utility; but it is far less abundant. The constant association of copper with iron and of silver with copper in nature is as remarkable as the presence of silver in all, or almost all, gold. There is scarcely a ferruginous ore, soil, or water which does not contain at least a trace of copper, and it may be, perhaps, safely said that wherever iron or its compounds occur in nature there also will copper be found in some form or other. And probably this union extends beyond the limits of this earth, for even meteoric iron contains appreciable quantities of copper. According to some authorities this element occurs in all the plants and animals which have been examined for it; thus it is said to have been detected in sea weed, in the fluids of mollusca, in the blue blood of *Limulus*, in flour, hay, eggs, cheese, meat, &c. In the mammalia, and perhaps also in the other classes, the copper salt generally accumulates in the liver rather than any other part of the body. [Copper, A. and Sci. Div. cols. 192, 193]. Some caution, however, is required in accepting the general presence of copper in animals and plants, since the method adopted for detecting it is not always to be relied on. For example, Ulex, using a brass blowpipe, reports that every substance he examined showed minute traces of copper, while Lassen, who used a blowpipe with a glass nozzle, failed in detecting the element in many of the substances examined by Ulex. Lassen, therefore, inferred that the copper was introduced from the brass blowpipe. Other metallic blowpipes, especially those with iron nozzles, may give rise to a similar error.

The abundance of its ores and the comparative ease with which it may be reduced from them rendered copper one of the earliest of the useful metals sought for by man. Archæologists tell us that as a nation advances in civilisation it changes its weapons of stone for those of metal; and that while the early Americans used native copper, the early inhabitants of Western Europe employed it, in conjunction with tin, in the form of bronze. As yet few indications have been met with showing that there may have been a period when the early Europeans used copper implements, but it seems not unlikely there was such a period, considering that tin is found in but few places, and the small probability of the processes for obtaining copper and of making bronze having been simultaneously discovered. The rarity of copper implements amidst the archaic relics of Europe may arise from their having been melted down and converted into bronze.

The abundance of these old implements, both in Europe and America, necessarily implied considerable mining activity; but it was not until about 1851 that traces of the old mines were discovered. No tradition exists amongst the present generation of Americans that their forefathers possessed copper mines, neither did they themselves have any knowledge of such mines until very recently. The discovery was mainly a consequence of the copper-mania which excited the people of the United States during the years 1844-1847. It was in the last-mentioned year that an agent of one of the companies found a cave, inhabited by a number of porcupines, which showed signs of having been excavated by man. On clearing away the rubbish he exposed a copper vein and several specimens of the stone mauls and hammers used by the ancient workmen. Further investigations showed that similar excavations, having an average depth of about 30 feet, were scattered thickly over an area nearly 150 miles in length along the southern shores of Lake Superior. All the copper districts lately discovered in this region were known centuries ago to the then inhabitants of the land, and were subsequently clean forgotten. The old excavations were so completely obliterated by long continued accumulations that the site of a copper mine could not be distinguished from the surrounding country, except perhaps by the mounds formed by its side. The trenches have been filled with soil and decaying vegetable matter, which is said to be of gradual natural accumulation, while over both the mounds and filled up trenches several generations of trees have succeeded each other. Mr. Whittesley has stated that many of the trees now flourishing in the gathered soil of the abandoned trenches are upwards of three hundred years old, and that "on the same spot there are the decayed trunks of a preceding generation, or generations, of trees that have arrived at maturity, and fallen down from old age." There are no precise data for ascertaining either when these mines were worked, or by whom.

In Spain there is another example of extensive mining operations having been carried on many centuries ago, as well as of the obliteration both of the old workings by accumulated rubbish, and of the remembrance of them by the lapse of time. In this case, however, it was well known that mining operations had been carried on in the same district by the Romans and by the Spaniards, from the commencement of the Christian era up to the middle of the sixteenth century. From the latter period to 1853 the mines were quite neglected. They are situated near Huelba, at the mouth of the river Tinto, and have been described by E. Deligny in the 'Revista Minera' for 1863. He thinks it probable that the mines were first worked by the ancient Iberians several centuries before the present era, and before the arrival of the Phœnicians in the country. The extent of the excavations is indicated by innumerable shafts, by the ruins of large villages, and by colossal heaps of débris. The time during which they were most energetically worked is shown by these heaps. Sections of them reveal two markedly distinct kinds of material, the results of two different methods of treating the ore. The materials are arranged in regularly stratified bands, the lowermost of which belong to the Phœnician epoch, while those above were deposited during the time of the Romans. These mines are again being worked on an extensive scale, their development having been mainly brought about in the following curious way. Early in this century the alkali trade was established in the north of England, and was more especially concentrated round Newcastle and in Lancashire. The alkali was, for the most part, obtained by treating common salt with sulphuric acid, and the sulphuric acid was made almost entirely from sulphur imported from Sicily. The trade soon increased to such an extent that great inconvenience was experienced from the insufficient supply of sulphur, and the variations in its price. Still further inconvenience was felt when its price rose considerably in consequence of the vine growers using large quantities to check the vine disease. The alkali manufacturers then sought for other sources of sulphur, and found it in the copper pyrites of various countries, and amongst others that of Spain and Portugal in the district near Huelba. This ore, however, contains so little copper, that it is unprofitable as a source of that metal, but it has become profitable now that the alkali makers utilise both the sulphur and the copper which it contains. This, we may mention, is the origin of the introduction of the manufacture of copper in the Newcastle district.

The properties of copper will next be considered; but this task is beset with many difficulties, inasmuch as the facts recorded generally apply to copper in a more or less impure state, and in different conditions, while no indications are given either of the impurities or of the conditions. Absolutely pure copper has considerable resemblance to pure iron in toughness, malleability, ductility, and tenacity, while it is equal to silver as a conductor of electricity. The copper and iron of commerce not only present wide differences in properties, but each comprises a multitude of varieties differing from each other.

An illustration of this is afforded by the specific gravity. Thus, in COPPER, E. C., A. and Sci. Div., the specific gravity is stated to be 8·78-8·96, according to manipulation; while COPPER, E. C., Nat. Hist. Div., has 8·58. The latter may be a misprint, but, as will be seen presently, many specimens of copper may be even lighter than this. Native crystals of copper have a specific gravity of 8·94. Electro-deposited copper varies from 8·84 to 8·91; but when it has been wiredrawn and annealed it is increased to from 8·91 to 8·94. The best copper wire is generally 8·94, but in some rare cases it has been as high as 8·958, while Marchand and Scheerer record a crystal of copper with a specific gravity of 8·962, which, however, was found to contain gold, silver, and iron in appreciable proportions. When copper is melted, and allowed to cool in air, it remains quiescent at a high temperature; but just before it approaches the point of solidification, the surface appears to boil, and a reddish haze seems to rest upon it, while globules of metal of considerable size are thrown up to a height of several inches. The surface then solidifies, a ridge is formed across it, and the whole mass of metal expands. When cold, its specific gravity is about 8·58, but generally somewhat less. On making a perpendicular section through the cold mass, with its original surface uppermost, a number of elongated cavities will usually be seen extending from the sides to minute crater-like prominences, in or near the central ridge; and on examining the metal closely with a lens its structure will be seen to be minutely vesicular. The colour is of a deeper red than in denser copper, while there is an absence of the silky lustre which characterises compact copper. When sufficiently pure copper is fused under charcoal, and left to cool, no spitting occurs, the mass does not expand, a depression, not a ridge, is formed on the upper surface, the structure is not vesicular, and the specific gravity is high. The specific gravity, then, is more or less influenced by the degree of vesicularity of the mass, and this depends upon the evolution of a gas. Pure compact copper has a definite specific gravity, viz., 8·94 at a temperature of about 60° F., and under the ordinary atmospheric temperature.

It has just been noticed that the vesicularity of copper is caused by the evolution of a gas, but there is considerable difference of opinion as to the origin of this gas in ordinary copper. Some authorities state that copper, like silver, absorbs oxygen at a high temperature, and gives it out again at a lower one; others that cuprous oxide is formed, and subsequently decomposed by charcoal, with formation of carbonic oxide, which escapes; and others think that oxygen, acting on the sulphur in the metal, may give rise to sulphurous acid. So far as we have examined the evidence, it appears probable (1) that the phenomenon is not due to the absorption of oxygen; (2), that, as Dick, Matthiessen, and Russell have shown, it is produced when copper is fused under charcoal, with accession of oxygen, being then due to the second cause mentioned; (3), that the presence of sulphur and formation of sulphurous acid, may occasionally be the efficient agents; and (4), that it may be produced by the absorption of certain gases, amongst which are hydrogen and carbonic oxide. The first and second points are now generally admitted, the facts in favour of the third (Percy's Metallurgy, vol. i. p. 272) are not decisive; so that we need refer only to the experiments in support of the fourth. These were made by Caron (Comptes Rendus, lxiii. p. 1129). He states that when copper is fused in a porcelain vessel in a current of hydrogen its surface becomes covered with bubbles of gas, which gas is aqueous vapour, formed by the union of the hydrogen with the oxygen contained in all commercial copper. When all the oxygen has been carried off the metal is as brilliant and fluid as mercury. On allowing the mass to cool the surface is agitated with a boiling action, due to the escape of a gas which scatters the metal in all directions. The cold metal is filled with cavities, has a dull non-crystalline appearance, and a specific gravity of 7·2, while before melting its specific gravity was 8·8. The phenomena are attributed to the absorption of hydrogen at a high temperature, and its liberation at a lower one. The same effects are produced when carbonic oxide is used. When, however, the metal is fused in a vessel composed of lime, graphite, or other material capable of absorbing the hydrogen and carbonic oxide, no ebullition-like effects are produced, and the metal retains its compactness. Fused silver and tin do not absorb hydrogen, but when exposed to a current of that gas their specific gravity is increased in consequence of being deprived of the oxygen generally contained in them.

It has been admitted that most copper contains oxygen, and it has been stated that the gas probably is not absorbed by the metal. If so, it must exist in some combined state. It is known that at a low red heat copper will combine with oxygen, and that it combines more readily with it at higher temperatures. This fact alone indicates the improbability of the gas being simply dissolved when the metal is fused. It appears that cuprous oxide is formed, and that this substance is soluble in copper. It is the presence of this oxide which renders copper what is technically known as *dry*. It causes the metal to be brittle both when hot and when cold; to have a granular, not fibrous, fracture, a dull lustre, and a deep purplish red colour. The tenacity is much diminished; thus 1·1 per cent. of the oxide deprives the metal of much of its malleability, so that when worked in the cold state it splits and cracks, although it can be beaten out when hot. With 1·5 per cent. of the oxide it is brittle both hot and cold. The best commercial copper, or what is called *tough pitch*, has a close-grained fracture, a compact structure, a fine pale red colour, a silky lustre, and a high degree of toughness or malleability. In fact, it approaches very closely to pure copper in its properties, and yet it contains a considerable proportion of the cuprous oxide—frequently more than 1·5 per cent. There is, however, one important difference between *tough pitch* and *pure* copper, viz., when the former is subjected to a stream of hydrogen, so as to reduce the oxide, it becomes exceedingly brittle, loses its lustre, and acquires a high degree of porosity; when pure copper is subjected to the same treatment its malleability and structure are unaltered. Here, then, we have a remarkable case of two specimens of metal almost identical in their properties and external characters, which, when subjected to the same treatment, may be rendered totally unlike; the one may be bent backwards and forwards frequently without breaking, while the other will snap rather than bend. And we have the further apparent anomaly that the metal is malleable when pure, but on adding 1·5 per cent. of cuprous oxide it becomes brittle, granular, dull, and dark red; while the other specimen contains 1·5 per cent. or more of the oxide, is malleable, fibrous, silky in lustre, and pale red, but on reducing the oxide to the metallic state the mass becomes brittle, dark red, dull, and granular. The explanation, according to Karsten and Percy, is that the presence of small quantities of cuprous oxide, *or* of certain metals, such as lead and antimony, renders *pure* copper brittle, but if cuprous oxide is present *with* the metallic impurities, the copper retains its malleability.

Minute proportions of impurities also have a marked effect in diminishing the conducting power of copper for electricity. Thus, calling the conducting power of silver at about 15° C., 100, Matthiessen found that unmelted electrotype copper would be represented by 93·46 at 20°·2 C. Assuming this kind of copper as a standard, and calling its conducting power 100 at 15°·5 C., he obtained the following results. Except where otherwise stated, the coppers are commercial, and all the specimens were in the form of annealed wires.

	Conducting Power.	Temperature.
Pure electro-deposited copper	100·	15°·5 C.
Lake Superior, native, not fused	98·8	”
Ditto, fused, as it comes into commerce. Contained traces of iron, cuprous oxide, and silver	92·57	15° 0 C.
Burra Burra. Traces of iron and cuprous oxide	88·86	14°·0 C.
Best selected. Traces of iron, nickel, antimony, cuprous oxide, &c.	81·35	14°·2 C.
Bright copper wire. [Impurities in it not known.]	72·2	15°·7 C.
Tough cake. Traces of lead, iron, nickel, antimony, cuprous oxide, &c.	71·03	17°·3 C.
Demidoff. Traces of arsenic, iron, nickel, cuprous oxide, &c.	59·34	12°·7 C.
Rio Tinto. 2 per cent. arsenic, and traces of lead, iron, nickel, cuprous oxide, &c. . . . ·	14·24	14°·8 C.

These results were obtained with what Matthiessen terms *ordinary* experimental care, but more recently he has performed another set of experiments upon the conducting powers of metals in which *great* as distinguished from *absolute* care was employed. These later results are thus stated by him. The figures express the resistances of one gramme weight, having a length of one metre in terms of the British Association unit of electrical resistance. They therefore show the absolute amount of resistance, but as we only wish to refer to the relative resistances, we need not stop to indicate how.

Copper	·1469
Silver	·1682
Gold	·4150
Gold-silver alloy	1·668
Lead	2·257
Mercury	13·06

From which it appears that *pure* copper is a better conductor than *pure* silver, and that unmelted electro-deposited copper is inferior to pure copper. As the specific gravity of the copper which conducts better than silver is not stated by Matthiessen, a conjectural explanation of the difference is offered. Electro-deposited copper has a somewhat lower density than most other compact pure copper, and even when made into annealed wires it ranges from 8·91 to 8·94, as already stated. Moreover, such copper generally contains traces of sulphur derived possibly from the solution of sulphate of copper from which it has been deposited. The combination of low density with the presence of sulphur would lessen the conducting power, and may have been present in the standard copper. Supposing, however, it was free from sulphur, a difference might be produced according to the care bestowed upon drawing the wire. It is exceedingly difficult to obtain a good wire, so that doubtless a better one would be obtained with great than with ordinary care.

Stated shortly, then, the physical properties of copper are that it is 8·94 times heavier than its own bulk of water, or 99,931 times heavier than an equal volume of hydrogen at a temperature of 0° C., and under an atmospheric pressure of 760 millimetres; that it has a pale red colour, a fibrous compact structure free from porosity visible with an ordinary lens, a silky lustre, a high degree of malleability both hot and cold, and a specific heat of ·095; that its malleability is not diminished by fusing it in hydrogen, ammonia (gaseous), or carbonic oxide; that it contracts on solidifying; and that it probably surpasses silver in its power of conducting electricity. If its specific gravity is lessened, or if it contains impurities, these properties will be more or less modified. Nothing has been said as to the fusing point of pure copper, because all the writer knows is that Pouillet estimates it at about 1500° F., and Daniell at about 2538° F. Both cannot apply to pure copper, and perhaps neither does.

The chemical properties of copper will now be considered, but the description of these also has its difficulties, for want of knowing what are the precise surrounding conditions requisite to produce certain definite effects, and what is the physical condition of the copper.

In dry air or oxygen compact copper is unaffected at ordinary temperatures. On heating it to redness it combines with the oxygen to form the cuprous oxide, which contains 11·2 per cent. by weight of oxygen. This oxide melts between a bright red and a white heat. If, however, the metal is in a finely divided state cuprous oxide is formed at a temperature far below redness. The cuprous oxide may be heated to redness for a long time without passing into the cupric oxide, which contains 20 per cent. of oxygen; but if it is first powdered, and then exposed to the same temperature, it rapidly passes into the cupric oxide.

Moist oxygen has no effect on compact copper, but if assisted by a weak acid, say carbonic acid, carbonate of copper is formed at the ordinary atmospheric temperature; and if assisted by alkaline and saline solutions, one or other of the oxides is formed. It combines (when compact) with mercury, and (when in filings) with chlorine at ordinary temperatures, and at a red heat with sulphur, selenium, silicium, and all the metals.

Although copper and its ores are so widely distributed that scarcely a country or geological formation is without them, yet a study of such distribution leads to the recognition of a few important general truths. The most abundant ore is copper pyrites, and next to it, perhaps, comes copper glance; these generally occur either in true or in segregated veins in hard and crystallised rocks, the age of which is generally assigned to the lower Silurian period. The other ores, such as the oxides, carbonates, and, generally speaking, all which contain oxygen as an essential constituent, occur sometimes in segregated veins, but more commonly dispersed through a sedimentary stratum; they are also found in the more or less decomposed upper portions of the pyritous veins. Native copper is found under the same conditions as the oxides, carbonates, &c. The members of this second group are found in strata of Silurian or post Silurian age. It includes the silicate (dioptase), which it may be noticed is rare as an ore—a circumstance which, taken in conjunction with the abundance of the sulphides, is a good illustration of the relative chemical affinities of silica and sulphur for copper under most natural conditions. In this respect copper somewhat resembles iron, but there is one marked difference between them, viz., that although their respective silicates are rare, the oxides of iron frequently form an important constituent (or are present in small quantities) in many compound silicates, while the oxides of copper are so rare in silicates that we do not know that a single instance has been recorded of a native silicate which contains even 1 per cent. Many of the rocks of Malvern and elsewhere contain traces or quantities of less than 1 per cent. There are a few instances of artificial cupriferous compound silicates, such as the orthoclase-like crystals found in the copper-smelting furnace at Sangerhausen, which contained ·30 and less per cent. of cupric oxide. The relation observed between the sulphuretted and oxidised copper compounds seems to indicate that the former are the first formed, and that the latter are derived from them by the action of the oxygen and carbonic acid of the air or of the waters. In speaking of the sulphides as being first formed, we refer only to their mode of occurrence in veins, without wishing to convey any opinion as to how they came there, or to the previous history of their constituents. The metal may or may not have been in the state of oxide, carbonate, &c., long before it entered the vein as sulphide.

Let us then see whether the minuter details do or do not support these general inferences, and for this purpose we propose to consider a few of the principal cupreous deposits, and to take them up somewhat in the order of their geological age.

The ores occur in several distinct ways. Sometimes they are disseminated through a sedimentary bed; sometimes they are collected at the junction of two dissimilar rocks; sometimes they form segregated veins; and sometimes true veins.

Most of the deposits found in the oldest or most crystalline rocks occur as true veins. It is only in a few instances that geologists have been able to ascertain the age of the rock which they traverse, and therefore all those presenting certain characters are here assigned to the Palæozoic period, which embraces all rocks earlier than the Trias.

The copper mines of Norway are the most northern of those worked in Europe, and probably their ores are (geologically) the oldest known. At Kaafjord, where slates and what are called igneous rocks are in contact, the ore occurs in veins in the latter, and rarely in the former. At Raipasvara Mountains similar veins are developed in a crystalline limestone. At Bandag a vein traverses crystalline schists near their junction with a granitoid gneiss, and contains quartz, mica, copper pyrites, erubescite, galena, blende, and native silver. At Noesmark and Mosnap cupreous sulphides are contained in the veins of granite which pass into mica schist; while at Moberg similar ores are contained in the quartz veins which cut through hornblendic schists. When these schists are soft some of the ores are met in them, also, in the neighbourhood of the intruding veins. At Haukum the mica schist contains nodules of granite, in which erubescite occurs associated with molybdenite, garnet, epidote, and traces of copper pyrites, while cavities in the nodules hold native silver, heulandite, and laumonite. At Röraas the ores are disseminated through chlorite slate, so as to form metalliferous layers or *fahlbands* parallel with the bedding of the rock. This last is the usual mode of occurrence in Sweden, as at Åreskuttan, Gustavsberg, and Garpenberg. The deposits at Fahlun may also be of the same kind, but they have a peculiar character. The ore is mainly copper pyrites; it is intimately associated with chlorite, and is so arranged in curved undulating lines that the rock appears to be made up of little oval masses, which are called *skölar* by the miners. Galena and blende are also associated with it.

In Cornwall the ores are mostly in veins situated near the junction of the slates or *killas* and the granite. The most abundant are copper pyrites and copper glance; and they are most highly developed sometimes in the slate, and sometimes in the granite. They occur in bunches or large lumps in a gangue chiefly composed of quartz or fluor spar, and are generally considered to be more concentrated in the pale blue coloured slates than in those which are reddish or brown; and in the soft granite than in the hard. Carbonate of lime, barytes, and wolfram are rare, while iron pyrites and chlorite are common associates of the copper ores. The chlorite is more particularly abundant where the richest ores are met with, while the fluor spar is especially characteristic of the St. Francis, Bassett, Buller, Kelly, Bray, Gunnislake, and Bedford United mines. Galena and blende are of general occurrence. These remarks apply only to the deeper part of the lodes. The upper portions are generally more or less decomposed to a depth of from 150 to 200 feet, and form the *gossan* of the Cornish, the *eisernen Hut* of the Germans, and the *chapeau de fer* of the French. The characters which it presents afford useful indications of the value of the deeper part of the lodes. It is composed of a mixture of quartzose matter and peroxide of iron, containing variable quantities of the oxides, carbonates, and arsenates of copper and other metals. Gold and cassiterite are frequently present in considerable quantities. These, in fact, are the products which we should look for as a consequence of the action of water containing oxygen and carbonic acid upon copper pyrites or on copper glance and iron pyrites through which gold and cassiterite are sparingly distributed. The oxygen and water oxidise the sulphur, copper, and iron; the sulphuric acid thus generated readily combines with the cupric oxide to form the soluble sulphate of copper, but does not combine with the ferric oxide. The latter combines with water and passes into the insoluble hydrated ferric oxide, and this remains behind with the insoluble gold and cassiterite. Sometimes the oxides of copper do not combine with sulphuric acid, but remain as cuprite, melaconite, or copper smut, and tenorite; under other circumstances the carbonates, malachite and chessylite, are formed, and frequently oxides and carbonates occur together. The association of these oxidised forms of copper ore with the conditions that evidently facilitate the action of moist oxygen and weak acids will go far to explain why these forms are so predominant in the sedimentary beds, as will be noticed presently. The age of the formation of the gossan is subsequent to that when the vein was filled with the sulphides and their gangues.

Some of the Austrian mines appear to have a resemblance to the Norwegian. Those at Tachauer, Schmelzthal, Grasslitz, and Gursaupa are principally worked in veins containing copper pyrites, and traversing crystalline schists. At Hohenthal in Silesia the copper and iron pyrites form a bed in crystalline schists, and are accompanied by malachite and chessylite.

The most remarkable deposit in Italy is that at Traversella in Piedmont. It appears to occur at the contact between syenite and mica schist, and to be composed of magnetite through which other minerals are distributed. Copper pyrites is met with in large lumps, while hæmatite, galena, blende, pyrrhotin, mispickel, antimonite, molybdenite, fluor spar, calcite, dolomite, mesitin spar, quartz, chlorite, garnet, augite, hornblende, and traversellite also occur.

The mines of the south of Spain and Portugal are mostly situated on a vein which extends from Rio Tinto in Spain to the Atlantic shores of Portugal, and which has been followed for 150 miles. The principal ore is iron pyrites, through which threads of sulphide of copper ramify in all directions, while small quantities of galena and blende occur at intervals. The vein is situated in a rock intermediate in character between an argillaceous schist and a mica schist, amidst which considerable thicknesses of quartziferous porphyry is interbedded. The line of the metalliferous zone is well defined by the 'iron hat' which covers it, so that it is readily distinguished from the neighbouring schists. Mineralogically this is a ferruginous rather than a cupreous deposit, but it is mentioned here since it derives much of its commercial value from the copper it yields.

The mines of the Cape of Good Hope occur in gneiss and granite. The ore is copper pyrites associated with molybdenite, as also with the oxides and hydrosilicate of copper. Several lumps of native copper and gold have also been found.

The precise age of the foregoing has not been determined, but the phenomena they present suggest that while most may be pre-Silurian, the Rio Tinto vein will possibly be found to belong to the Silurian formation; those of Cornwall are in Devonian strata; while those which we are about to mention certainly occur in Silurian rocks. At Pfundererberg, a few miles to the north of Klausen in the Tyrol, three veins occur in an argillaceous mica schist associated with porphyry. They have a strike of N.E. to S.W., and dip at a high angle towards the S.E. The gangue is principally quartz, and the ore varies according to the depth, being argentiferous galena and blende at the top, copper and iron pyrites lower down, while still lower the iron pyrites gradually disappears, until copper pyrites is alone met with. A short distance south, and to the east of Trent, is a range of granite rocks bordered on both its north and south flanks by mica schist. In this district are several quartzose veins bearing copper pyrites, which have a N.N.E. and S.S.W. strike and an almost vertical dip. Farther eastward, in the neighbourhood of Salzburg, occur another set of deposits of a somewhat different character. The copper pyrites occurs in beds in chloritic schist conformable with those of the containing rock, and like them having a northerly dip. These localities are on the north slope of the Noric Alps. On the southern flanks of the same Alps, near Brunecken, there is a similar bed of copper pyrites intercalated amongst chloritic schists, and dipping with them towards the south. Copper pyrites occur under the same circumstances in the valley of the Moll in Carinthia, so that this is apparently an eastern extension of the deposit near Brunecken. There are other localities still further east, near Leoben and Eisenerz, where the chlorite schist seems to have more the character of an argillaceous schist containing a little chlorite. It is very unusual for copper pyrites to occur thus in stratified layers without being accompanied by oxides and carbonates. The deposits on the east flanks of the Ural Mountains are situated in an upper Silurian limestone, but they have much the appearance of having been introduced long subsequent to the formation of the limestone itself. The limestone is interbedded with trap, and at the line of contact between the trap and limestone are layers of clay in which the copper ores, mostly red oxide and malachite, are found in bunches and nests. Occasionally immense blocks of malachite lie in the hollows of igneous rocks mixed confusedly with fragments of the neighbouring strata. One such mass had an estimated weight of 580 tons, and according to Whitney "appears to have been deposited from a cupriferous solution in a manner analogous to that of a stalagmite." The rarity of copper pyrites and other sulphides in these Russian localities contrasts strongly with the predominance of those compounds in the Silurian strata of the Tyrol and Austria.

The copper ores of the older rocks of America will now be considered. On the north shore of Lake Huron metalliferous veins occur in a gangue of quartz, situated in a hard quartzite interbedded with thick masses of trap. These rocks have been assigned to the age of the Potsdam sandstone, the lowest of the fossiliferous rocks of the United States, and corresponding probably to the *Lingula* flags of Great Britain. As, however, sandstones and conglomerates, continuous with those which contain the copper ores at Keweenaw Point, overlie them, the Lake Huron deposits must be older than those of Lake Superior. These latter are generally admitted to be of the age of the Potsdam sandstone, and if correctly so, then the Lake Huron deposits are of pre-Potsdam age. The ores are entirely sulphides, and principally copper pyrites.

The copper ores occurring along the eastern slopes of the Appalachian Mountains from Vermont in the north to Georgia in the south, upwards of thirteen degrees of latitude, have a marked community of character. They form segregated veins in the most highly crystalline rocks, whose strike conforms with that of the axis of the range. The principal ore is copper pyrites, but the upper parts of the veins are frequently capped with gossan, composed of oxides of copper and iron, erubescite, and the carbonates of copper. So similar are these deposits that the description of one will apply in all general points to the others. The Springfield copper mine in Maryland may be taken as an example. The description we quote is given by Whitney, as based upon a manuscript account by Mr. Dieffenbach. "This mine is situated in Carroll county, about one mile north of the Sykesville station of the Baltimore and Ohio Railroad. At this point the vein runs N. 25° E.; it underlays 13° to the S.E. for the first sixty feet, then descends vertically for the next forty feet, then underlays 8° to the N.W. for a depth of 100 feet, and from that point, so far as it has been opened, a depth in all of 240 feet, it descends perpendicularly. The vein is twenty to twenty-four feet wide at the surface, and in depth never falls below six feet. At the surface, and for a depth of sixty feet, it consists of quartzose, magnetic, and specular oxides of iron. Here copper ores begin to be found disseminated in the vein, and the quantity increases with the depth. Copper pyrites predominates with some variegated ores; iron pyrites is also invariably found in the vein, and is sometimes auriferous." This vein was first worked for its iron, but subsequently for its copper. At first scarcely any copper was met with, but at a depth of about 100 feet the ores yielded about 13 per cent. of the metal; at 160 feet about 15 per cent.; and at 240 feet about 20 per cent. Were we to quote fifty other descriptions, we should find the following general features: a north-easterly strike; a slight dip near the surface, increasing to a high one or to verticality lower down; a preponderance of iron oxides at the top, gradually giving way to copper pyrites in descending; and the general occurrence of auriferous iron pyrites. The containing rock is either a talcose, a chloritic, or a hornblendic schist. The Tennessee veins are characterised by most of these general points, but they present a slight variation, which renders them more especially noticeable. The gossan is more than usually abundant, and between it and the undecomposed portion of the vein is a thick black band composed of copper smut, or *tenorite*, mixed with a little siliceous matter, sulphide of iron, and sulphate of copper. The peculiarity here is the accumulation of the black oxide of copper, which is probably due to the high dip of the enclosing schists, and to the position of the outcrops of the veins at the summits of ridges. According to Whitney, these schists are of lower Silurian age, but the following facts seem to indicate they are pre-Silurian. They belong to the oldest groups of rocks in Tennessee, and are overlaid unconformably by the Chilhowee sandstones, which are the representatives of the Potsdam sandstone of the United States.

As already indicated, the copper deposits of Lake Superior occur in beds of the age of the Potsdam epoch. In most parts of America this period was marked by an accumulation of sandstone of remarkable purity, followed by a limestone. The deposits are usually almost horizontal, and not more than a few hundred feet thick. In the district near Keweenaw Point they acquire a thickness of several thousand feet, owing to the interbedding of immense masses of igneous rocks, while the strata are much disturbed. This 'Trap Range,' as it is called, has a width of from two to six miles, and extends in a N.E. and S.W. direction from Point Keweenaw to far away into Wisconsin. It consists of three or more nearly parallel ridges, made up of a series of compact granular, amygdaloidal traps, with occasional intercalations of sandstones and conglomerates. The lithological character and mechanical structure of the trappean rocks is described as being variable. The usual mineral constituents are labradorite and augite, with a smaller proportion of various other minerals, among which magnetite, chlorite, and epidote, are the most abundant, while zeolitic minerals and calcspar occur as accidental ingredients. The ore is mostly native copper, which occurs in small masses and grains disseminated through the trap, and occasionally in minute quantities through the associated sandstones and conglomerates. The cavities of the trap are filled with calcite, quartz, chlorite, and zeolite. The great peculiarity of this district is the predominance of native copper, and as its occurrence in this form rather than any other is a matter which has to be explained, a few remarks seem necessary as to the use of the word trap, which will frequently occur in the remainder of the article. This word is adopted here because Whitney and other authorities have employed it, and because we know no substitute for it. Whitney evidently considers all the traps as ancient volcanic lava-flows, since he states it is apparent, from their mode of formation and position, that they were poured out from the interior of the earth at the time the deposition of the sandstone was going on, from a series of fissures which extended along the line now occupied by the metalliferous formation. In the more elevated and central portion of the range the igneous rocks predominate, containing intercalated beds of conglomerate of very inconsiderable thickness, between heavy masses of trappean rock. As we recede from the line of igneous action in either direction, we find that the belts of trap become thinner, the conglomerate predominates, but gradually disappears and is succeeded by the sandstone with its normal character. There are, however, two well marked kinds of trap, the one crystalline and compact, or a greenstone, and the other amygdaloidal. The greenstone yields little or no copper, while all the best workings are connected with the amygdaloidal variety, more especially where it presents the most distinctly bedded structure. It is also noticeable, that even in the case of fissure veins the copper is abundant in the amygdaloidal, but is immediately impoverished on entering the compact trap. In North Wales a strikingly similar condition of things prevailed at an epoch which, geologically speaking, was not widely separated in time from the volcanic eruptions of Lake Superior. Grits and shales occur amidst masses of volcanic matter, rivalling those of America in thickness. Here also the volcanic matter is thickest about certain centres, and gradually diminishes as we proceed from those centres, while the grits and shales as gradually acquire greater development. Here, also, the traps are divisible into two groups, the compact and amygdaloidal, the latter containing quartz, calcite, and chlorite in cavities. Indeed, there is so much resemblance between the rocks of the two areas that it is difficult not to believe that they were formed or placed in position under similar conditions. The North Wales district has been carefully surveyed by Professor Ramsay, and he repeatedly refers to the great difficulty met with in distinguishing the various kinds of volcanic rocks. His researches, however, led him to the conclusion that whereas the compact traps, *i.e.*, the greenstones and felspar porphyries, are intrusive, those which present a somewhat brecciated and amygdaloidal character are formed from the deposition of volcanic dust in the sea. It seems by no means improbable that further researches will show that the amygdaloidal traps of Lake Superior are felspathic ashes originally strewed over the bottom of a sea. The cupreous deposits associated with eruptive rocks in the Philippines and in Cuba, appear to have great analogy with those of Lake Superior.

Whitney divides the mines of the Lake Superior district into four groups, viz.: (1) Keweenaw Point; (2) Isle Royale; (3) Ontonagon; and (4) Portage Lake; of which the first and fourth only require notice here. In the first region the belt of metalliferous trap commences at the eastern extremity, and, like the land, gradually curves round towards the south. It is formed of two principal ranges, known as the greenstone and Bohemian. The greenstone is composed of a rock very similar to dolerite, and is several hundred feet thick; beneath it lies a conglomerate and a thin deposit, which Whitney describes as being like a consolidated volcanic ash or mud deposited on the floor of the ocean; beneath this again comes an amygdaloidal trap. Copper occurs in the ash-like bed. Most of the mines of Keweenaw Point are, however, worked in fissure-like veins, which strike right across the range, and are richest where they pass through the amygdaloidal beds. The gangue is principally quartz, accompanied by calcspar and zeolites, of which prehnite and laumonite are the most common. Many of the veins have a brecciated appearance, as though made up of fragments of the adjoining rocks, cemented together by quartz. Their strike is almost uniformly identical, and their dip is nearly vertical. The copper occurs amidst the gangue in pieces varying from specks to masses weighing hundreds of tons. One block, found between trap and conglomerate, was forty feet in length, and was estimated to weigh 400 tons, and to contain 90 per cent. of pure metal. It is remarkable that where these large blocks occur, the rocks for a considerable distance around are perceptibly impoverished, indicating, apparently, that it had been formed in some way by the aggregation of smaller particles. It is also remarkable that many of these blocks contain radiated nodules of prehnite.

The trap range of Portage Lake is formed of several zones, each of which is bounded by a conglomerate and sandstone. Each zone presents well marked peculiarities in the nature of its metallic deposits and of the minerals which accompany them. Passing from east to west, there are four zones known as Isle Royale, Pewabic, Hancock, and South Lode. They have been studied by Messrs. Williams and Blandy, whose description is mainly followed. The Isle Royale zone is about a mile and a half wide, and is bounded on each side by belts of conglomerate. The so-called lodes contain a large amount of epidote, but calcite is comparatively rare. A larger proportion of the copper occurs in big lumps than in the other zones. Near the eastern limit of this zone sulphides have been met with in considerable quantities, associated with quartzose vein matter and the arsenides of copper, Whitneyite and Domeykite. The Pewabic zone rests on the rocks forming the Isle Royale series, but is separated from them by a copper-bearing conglomerate and a contact vein. Epidote is here rare, while calcspar and laumonite are abundant. No sulphides have been met with. The Hancock zone is about 600 feet wide. Here, as in the previous zones, the copper is found in the amygdaloidal trap, but the associated mineral is chiefly chlorite. The South Lode zone rests on the Hancock series, and is about 2100 feet wide. The amygdaloidal traps are subordinate in importance to the sandstone and conglomerates, and have yielded but little copper.

The trap rocks of the Portage Lake series widen out towards the N.E., so that probably the traps in that direction may be continuations of those of Portage Lake, but with new beds intercalated between them. Towards the S.W. the rocks thin out, but in the Ontonagon district they again thicken and present characters scarcely distinguishable from the Isle Royale zone. Thus the copper is principally associated with epidote, and sulphides of copper have been met with.

The most important copper mine of Missouri, that of Stanton, is situated in a limestone assigned to the Potsdam epoch, but the character of the deposit has no resemblance to that of Lake Superior. The limestone is that called the Third Magnesian Limestone by Mr. Swallow, the geological surveyor of the State, and above it the Second Sandstone lies conformably in other parts of the State, but which appears to have been denuded at Stanton. The limestone has a slight dip towards the south. At Stanton there is what looks like a fissure of considerable width, unaccompanied by any faulting of the strata, and filled up with a debris of sandstone apparently belonging to the Second Sandstone of Swallow. The ores found were chiefly malachite and peroxide of iron, while sulphide of copper was present in small quantity. The formation of the fissure appears to be geologically very recent, while the filling up was evidently from above.

Some of the Canadian deposits resemble those of Lake Superior; thus, at St. Flavien is a thick mass of amygdaloidal diorite, which contains crystals of quartz and calcite, accompanied by native copper. While others more resemble those of Austria; thus, at Ascot and Leeds copper pyrites occurs in veins traversing micaceous schists, associated with chloritic rocks.

No workable accumulations of copper ore appear to have been met with in American rocks of Devonian or carboniferous age. Forbes mentions, in a cursory way, cupreous veins in the carboniferous formation of Vancouver's Island.

The great majority of the cupreous deposits in rocks of later age than the Palæozoic era are of a purely sedimentary character. They are most abundant in Permian and triassic strata, but a few have been recorded in the oolitic, cretaceous, and tertiary formations. The best known example of Permian date is the Kupferschiefer, or copper slate of Mansfeld in Prussia. The ore is disseminated through a bituminous marly slate, remarkable for the number of fish remains which have been found in it. At Mansfeld the slate has a thickness of from 10 to 20 inches, but the ore is most concentrated in a portion from 3 to 5 inches thick. The copper occurs as sulphides, oxides and native metal, *i.e.*, as copper glance, copper pyrites, erubescite, tetrahedrite, tenorite and cuprite; and these are associated with iron pyrites, galena, blende, iron ochre, nickel ochre, molybdenite, and occasionally native antimony, bismuth, and arsenic. This stratum, or one occupying a similar position, has a wide geographical distribution. Thus, it is met with at Eisleben and Sangerhausen near Mansfeld; it occurs in a large elliptical patch between Prague and Königgratz in Bohemia, but the principal ores in this part appear to be the green and blue carbonates, and the black oxide or copper smut; it is again met with at Riechelsdorf, where the fishes are covered with a thin coating of copper, indicating that the animal remains have effected the reduction of the metal; and analogous beds of the Zechstein of Russia have copper ore, chiefly the green carbonate, disseminated through them. Again, in Switzerland the Seinf conglomerate, which probably belongs to the Rothliegende or lowest division of the Permian series, and is overlaid by a quartzite and dolomite assigned to the Zechstein, contains copper ore both in veins and beds. The veins have a high easterly dip, and are composed of a grey felspathic rock associated with a green, talc-like mineral, quartz, and calcite. Sometimes the gangue is composed almost entirely of a reddish-yellow magnesian carbonate of lime, and then the minerals become richer and more abundant. The ores are argentiferous erubescite, copper pyrites, iron pyrites, tetrahedrite, molybdenite, hæmatite, and a little native silver. With these occur chrysocolla, malachite, chessylite, and other minerals indicating the action of carbonated waters upon the sulphides. The veins are thin when the rock is hard, but widen out when it is soft. In the latter case the rock bounding the vein contains more or less ore disseminated through it. The veins strike through the conglomerate as well as the overlying quartzite and dolomite. The layer of ore is confined to the conglomerate. This bed has a thickness of about 7 metres, and consists of quartz accompanied by dolomite and talc. The ore occurs in minute threads ramifying in all directions, and composed of grey copper or tetrahedrite, erubescite and copper glance. M. Troger attributes the presence of the ores in this bed to its having been connected with cupreous springs flowing out at the borders of the Permian Sea.

Next we come to a group of Triassic deposits. The first to be noticed is that in which the copper mines of Vaudrevange and its neighbourhood are situated. It occurs in the upper part of the Vosgien Sandstone series, which extends from Sarrebrück to Longueville in one direction, and from St. Avold to Sarrelouis in another. The copper occurs in the form of the two carbonates malachite and chessylite, which are distributed in nests, nodules, crusts, and threads. The beds containing them belong to the lowest part of the 'grès bigarré' or Bunter Sandstone. The Werfen schists of Carniola, which are assigned to the lower trias by some geologists, and to the upper trias by others, are remarkable for the copper ores they contain. At Chessy, in France, copper ores occur at the junction of mica schists with beds belonging to the 'grès bigarré.' In the older schists the ores were pyritous, but in the overlying sandstone they were principally malachite, chessylite, black oxide or tenorite, and red oxide or cuprite. In Massachusetts, Connecticut and several of the neighbouring states, there is an extensive series of sandstones associated with traps which is generally called the New Red Sandstone, the age of which is somewhat uncertain; but the general opinion is that they are triassic. The copper ores are most abundant at the junction of the sandstone with the traps, and consist mainly of cuprite, the carbonates, and some native copper.

The copper ores at Tsiklova, in the Banat, are believed to occur in the oolitic strata. Those of Jamaica are of cretaceous age. They occur in cavities in a limestone containing *Hippurites*, which is associated with a quartzose porphyry, itself traversed by cupriferous veins. The ores are principally the sulphides and the gangue quartz, or quartz and sulphate of baryta. In Algeria there is another deposit of cretaceous age. On the shores of Lake Djendeli, in the province of Constantine, tetrahedrite occurs in quartz veins in a hard, fine-grained rock, which is called by Coquand a *jaspe* or jasper. As this name has frequently been applied to a felspathic rock, it is not improbable this also may be one. Sulphate of baryta occurs in some of the cavities, and the tetrahedrite passes by decomposition into malachite and chessylite. The jasper contains *Chama ammonia*, a fossil characteristic of the Urgonien stage.

Such is a rapid summary of the geological and geographical distribution of the copper ores. The facts are not sufficiently precise to enable us to give any definite explanation as to the origin of the ores; but the great variety in the modes of their occurrence suffice to show that the same explanation will not apply to all districts. There are, however, a few conclusions which seem to be supported by the evidence derived from every district, viz., that when the copper ores are deposited in true fissure veins they are invariably sulphides; when they have been manifestly exposed to the action of air and superficial waters they are converted into oxides, carbonates, silicates, &c.; that the sulphides predominate in the earlier rocks, while the oxides, &c., are more prevalent in those of later origin; that, adopting Lyell's grouping, the ores are most concentrated in two periods, the one embracing the upper Cambrian and lower Silurian, and the other the lower parts of the Permian and Triassic series; and that it is probable that all native copper has been reduced from its compounds, generally the sulphide or arsenide. The frequent association of these ores with rocks which may be classed together as metamorphosed clays, and with others which appear to be old volcanic ashes, is a strongly marked feature in their history, as also is their more intimate association with quartz, chlorite, and epidote.

CRAG. [TERTIARY STRATA, E. C. S.]

CROCODILIA. An order of reptiles which embraces all the forms noticed in the articles ALLIGATOR, E. C. vol. i. cols. 120—126, and CROCODILIDÆ, E. C. vol. ii. cols. 196—207. It exemplifies the constant tendency of modern scientific efforts to raise the rank of a group, for it is almost co-extensive with what Cuvier called the genus *Crocodilus;* while his sub-genus *Crocodili*, has now become the family *Crocodilidæ*, as defined below.

The essential characters of the order are that the teeth are implanted in distinct sockets, and are arranged in a single row, a feature which is restricted to this order amongst living reptiles, but it is met with in the old *Plesiosaurus* of liassic times, and its allies which constitute the order *Sauropterygia*, of which there is no living representative. There is but one external nostril, which is placed at or near to the extremity of the snout; whereas in all other reptilian orders there are two external nostrils. The *Chelonia* present an apparent exception to this statement, for in them the external nostril is single in the skull, but it is double in the integument. Apparent exceptions also occur within the limits of the order itself. Thus in some species, such as the common Indian crocodile (*Bombifrons indicus*) the nasal bones project into the nasal aperture, while in the black African crocodile (*Halcrosia nigra*) these bones extend right across the aperture as a bar, but not as a dividing plate. The nostril itself is single. The anterior vertebræ have two lateral processes on each side, which give support to the double headed or bifurcated ribs, a character which differentiates the crocodilian from all other living orders, but assimilates it to some which are now extinct, viz., the *Anomodontia*, *Dinosauria*, and *Pterosauria*. These transverse processes are remarkable for their varying position on the vertebræ in passing from before to behind. On one of the earlier cervical vertebræ they are situated in the same vertical plane, the one low down on the side of the body or centrum, the other at the base of the side of the neural arch. In tracing them on the vertebræ in the backward direction, the processes gradually acquire a higher position, so that at the commencement of the dorsal series the lower process is on the junction line of the centrum with the neural arch, while the upper is at the summit of the last mentioned arch. Moreover, the higher process is more backwardly situated relatively to the lower one. In advancing along the dorsal series the lower process gradually approaches to the same horizontal level as the other, and finally amalgamates with it to form one process, the dual nature of which is indicated by its slightly fluted median portion. This feature is also found in most of the extinct orders. There are two sacral vertebræ, each of which has the centrum connected with its neural arch by sutural articulation. The tail is long and laterally compressed; the feet are short and more or less webbed. The skin is partially covered by membrane-covered osseous plates. The heart is four-chambered, and approaches in structure more nearly to that of the bird than is the case with the heart of any other existing reptilian order. It is probable that the extinct orders *Dinosauria* and *Pterosauria* possessed quadrilocular hearts. The nature of the articular ends of the vertebral centra presents no general distinctive feature, but it is observable that there is great variety in this respect. Thus, the older members, such as *Teleosaurus*, had both ends cup-shaped; in *Streptospondylus*, and others, the forward end was protuberant, and the hinder one cupped; while in the living forms the centra are cupped in front, and protuberant behind. These distinctions form the basis of the three sub-orders, *Amphicœlia*, *Opisthocœlia*, and *Procœlia*.

The principal general memoirs on the classification of crocodiles, published of late years, are those by Huxley, Gray, and Strauch. Huxley's paper contains an excellent account of the osteological differences of the various genera, while Dr. Gray's is the result of the careful examination of upwards of two hundred specimens, as embodied in a synoptical classification, but it manifests the usual character of Dr. Gray's labours, which is a tendency to make more groups out of the same number of species than almost any other zoologist. Thus, Dr. Strauch, who had copious materials at his command, recognises but three genera; Professor Huxley distinguishes seven genera; and Dr. Gray considers there are twelve. We have been unable to procure a copy of Strauch's memoir; but it may not be uninstructive to present a general comparative outline of the schemes proposed by Dr. Gray and Professor Huxley. Both agree in regarding the crocodilian group as an order, but Gray calls it *Emydosauria*, and Huxley *Crocodilia;* the difference is purely verbal. Both agree in considering that the living types of the order may be arranged into the three families, *Gavialidæ*, *Crocodilidæ*, and *Alligatoridæ*. The *Gavialidæ* is defined by Professor Huxley as having a very long slender snout; the teeth generally slender, sharp edged, and sub-equal. The two anterior mandibular teeth pass into grooves, one of which lies on each side of a beak-like prominence of the premaxillæ, which carry the two anterior upper teeth. The canines are received into grooves. The mandibular symphysis extends back to at least the fourteenth tooth, and is partly formed by the junction of the splenial bones. The premaxillo-maxillary suture is always strongly convex backwards. The posterior nares are situated more forward than in the *Crocodili*. The temporal fossæ are large. The feet are strongly webbed. The dorsal scales are not articulated, and there are no ventral scutes. The distinctive features, according to Dr. Gray, are the long slender snout, the nearly uniform size of the teeth, the reception of all the teeth of the lower jaw into grooves on the upper, those for the two anterior teeth, as well as for the canines, being situated on the front edge; and the continuity of the scutes on the neck and back into one shield. Both authors recognise two genera. Their definitions of *Gavialis* scarcely differ, but that of Professor Huxley has one or two characters not given by Dr. Gray. There are 27-28 teeth in the upper, and 25-26 in the lower jaw. The mandibular symphysis extends to the 23rd or 24th tooth. All but the hindmost side teeth have a backward inclination in the upper jaw, and a forward one in the lower, while both groups project somewhat outwardly. The anterior margins of the orbits are raised. The premaxillæ and the end of the mandible are greatly expanded. The premaxillo-maxillary suture reaches the level of the fourth tooth behind the canine notch. The only species known is the *G. gangeticus* of Bengal, Nepal, and Malabar. The second genus is called *Rhynchosuchus* by Huxley, which Dr. Gray states is a synonym for the *Tomistoma* of Müller. The dental formula is $\frac{20}{18}$ on each side. Most of the teeth in the lower jaw, and the hindmost ones in the upper, are received into interdental pits. The premaxillæ present scarcely any expansion; and the margins of the orbits are not raised. The premaxillo-maxillary suture does not reach the third tooth behind the notch. The nasal bones meet the premaxillaries opposite the ninth tooth, or far short of the external nostril. There is but one species known, and that frequents Borneo and New Guinea. It was originally named *Crocodilus Schlegelii*, then transferred to *Rhynchosuchus*, and now it is known as *Tomistoma Schlegelii*.

The *Crocodilidæ* are defined by Professor Huxley as having strong unequally sized teeth, the difference in size being most marked between the fore and hind teeth. The two anterior mandibular teeth are received into pits in the premaxilla, but the canines pass into grooves (which may be converted into fossæ), situated at the junction of the premaxilla and maxilla. The other mandibular teeth are received between the maxillary teeth. The symphysis of the lower jaw does not extend beyond the level of the seventh or the eight mandibular tooth. The premaxillo-maxillary suture may be either straight or strongly convex backwards. The divided vomers do not appear in the palate. The posterior nares look more or less backwards, and are transversely elongated. The supra-temporal fossæ are always open, and the feet are distinctly webbed. The dorsal scutes are not articulated; and there are no ventral scutes. Dr. Gray uses fewer characters, but these, so far as they go, agree with Professor Huxley's account. He refers to the strong unequal teeth, and notices that the ninth upper and eleventh lower are largest, laniariform, and fit into notches on the edge of the upper jaw. He further notices that the cervical scutes form a distinct shield from the dorsal, and that the nose of both sexes is simple.

Professor Huxley distinguishes two genera in this family, viz., *Crocodilus* and *Mecistops*; but Dr. Gray recognises seven, which will be mentioned below.

In *Crocodilus*, as understood by Professor Huxley, the teeth are always very strong and very unequal, the largest being the tenth in the upper jaw. The mandibular symphysis does not extend beyond the level of the sixth tooth. The cervical scutes are usually six in number, arranged in a two-rowed rhomb, and separated from the dorsal scutes by a distinct interval. The dental formula is $\frac{18}{15}$ on each side. In *Mecistops* the cranium is elongated, and the snout slender and gavial-like. The teeth are subequal, and $\frac{18}{18}$ in number on each side. The mandibular symphysis extends to the level of the seventh tooth. The cervical scutes are arranged in two transverse rows of two scutes each, and immediately adjoin those of the dorsal series.

Dr. Gray's synopsis of the same family runs as follows:—

1. The nape with a rhombic disk formed of six plates, which is well separated from the dorsal shield. The species belonging to this section form the normal crocodiles.

A. Nuchal scutella none. Dorsal scales in four or six longitudinal series; the outer series ovate elongate. Toes webbed; legs fringed. The intermaxillary bone produced, truncated, and converging on the sides.

Genus 1. *Oopholis.*—Face oblong; orbits with an elongated, longitudinal, more or less sinuous ridge in front. Nuchal scutella none or rudimentary. Cervical disk rhombic, of six plates. Dorsal plates uniformly keeled, in four or six longitudinal series; the vertebral series with straight internal edges, the outer ovate elongate. Legs acutely fringed; toes broadly webbed. Intermaxillary bone produced and truncated behind, the sutures sloping backwards and converging, and then transverse or sinuous. There are two species, viz., *O. porosus*, in which the dorsal scutes are in six rows, and those along the vertebral region are of an elongate form; and *O. pondicherianus*, in which there are four rows of scutes, those along the line of the vertebral column being broad in form. The first-mentioned is the *Crocodilus porosus* of E. C. vol. ii. col. 199; and the other is a species first described in or about 1860.

B. Nuchal plates four, or rarely two or five, in a cross series. The dorsal plates as broad as long, in four or six series.

a. The intermaxillary bones truncated behind, with a nearly straight premaxillary suture. Face broad, oblong.

* Toes webbed; legs distinctly fringed.

Genus 2. *Bombifrons.* The premaxillary suture straight, or rather convex forwards. The face oblong; forehead with nodules in front of the orbits, but no distinct preorbital ridges. Nuchal plates four, in a curved line; cervical plates six, in the form of a rhombic shield, distinct from the dorsal one. Dorsal plates oblong, rather elongate, all keeled, in six longitudinal series, and with two short lateral series of keeled scales. The legs fringed with a series of triangular elongated scales. Toes webbed. It includes two species. The first, *B. indicus*, is the same as *Crocodilus bombifrons*, *C. palustris*, and *C. trigonops* of E.C. vol. ii. col. 199. The second is *B. siamensis*, which is the same as *Crocodilus siamensis* of E. C. vol. ii. col. 199.

** The legs with an indented fringe of short narrow scales. Toes short, nearly free.

Genus 3. *Palinia.* The face oblong; forehead very convex, with a ridge in front of each orbit, converging in front and forming a lozenge-shaped space. Nuchal plates two or four, unequal. Cervical disk rhombic, of six large plates. Dorsal plates large, broad, in six series; the vertebral series nearly smooth, the lateral ones strongly keeled. The intermaxillary short, truncated behind the pre-maxillary; suture straight, transverse. There are two species: *P. rhombifera*, which is the *Crocodilus rhombifer* and *C. planirostris* of E. C. vol. ii. col. 199; and *P. Moreletii*, but its specific difference from the foregoing is not conclusively established.

b. The inter-maxillary bone elongate, produced and truncated behind; the sutures sloping backwards and converging, and then transverse or sinuous. Toes webbed; legs with a fringe of elongated triangular scales.

Genus 4. *Crocodilus.* Face oblong, depressed, without any ridge in front of the orbits. Nuchal plates four, in an arched series. Cervical disk rhombic, of six plates. Dorsal plates quadrilateral, as broad as long; the vertebral series rather the widest and most keeled. Intermaxillary produced behind. Only one species is recognised, viz., *C. vulgaris*, of which *C. marginatus* of Geoffroy is a variety.

Genus 5. *Molinia.* Face elongate; forehead swollen, convex, especially in the adult; orbits without any anterior ridge. Nuchal plates two or four, small. Cervical disk rhombic, of six plates, the side plates generally small. The legs fringed with a series of triangular elongate scales. Toes webbed. Scales of the fore-arm and thigh thin, smooth. Muzzle oblong, elongate, slender, with a swollen convexity on the middle of the face before the eyes. Nostril not separated by a long ridge, the internal posterior nostril with an oblong sloping opening; the intermaxillary suture produced behind between the ends of the maxillæ. It includes two species, viz., *M. americana*, which is the same as the *Crocodilus americanus* of E. C. vol. ii. col. 199; and *M. intermedia*, which is the *C. intermedius* (Graves) of E. C. vol. ii. cols. 197; 199.

II. Nape with a broad, flat-topped shield formed of two or three pairs of plates, strongly keeled on each side, and nearly continuous with the dorsal shield. Legs fringed; toes webbed.

* Face broad; nasal bone produced into the nostril.

Genus 6. *Halcrosia.* The premaxillary suture transverse, rather convex backwards. Nasal bones produced beyond the intermaxillary, and forming a bony septum between the nostrils. The palatine bone produced to the same level as the lateral opening—that is, to the lateral inflection of the skull. The face oblong, broad, without any ridge in front of the orbit. Eyelids with two bony plates. Nuchal plates four, in a cross row, strongly keeled. Cervical plates three or four pairs, forming a ridge on each side, the hinder one small. Dorsal plates in four series; the central broad, slightly keeled; the outer narrow, distinctly keeled; sides with large convex scales. The only species, *H. nigra*, has long been confounded with *Caiman palpebrosus*, to which it has much external resemblance.

** Face very long; nasal not reaching to the nostril.

Genus 7. *Mecistops.* Face subcylindrical, scarcely dilated in the middle; orbits simple. Nuchal shields numerous, small, in two cross series. Cervical disk narrow, containing two or three pairs of plates. Dorsal plates small, all keeled, in six longitudinal series, lateral ones narrowest. Intermaxillary produced behind, and embracing the front end of the nasal. There is but one species, *M. cataphractus*, with which *M. Bennettii* of E. C. vol. ii. col. 198, is synonymous.

The third family, or that of the *Alligatoridæ*, as defined by Professor Huxley, have strong unequal teeth, those in front differing in shape from those behind. The anterior pair of mandibular teeth and the fourth pair fit into pits on the margins of the premaxilla and maxilla; while the mandibular teeth in the rear of these pass inside those of the upper jaw. The mandibular symphysis usually stops short of the level of the fifth tooth, but never extends beyond it. The premaxillo-maxillary suture is either straight or convex forwards. The posterior nostrils are wide; they have a downward aspect, and are situated forwards on the palate. Dr. Gray's definition does not materially differ from this.

Both authors recognise three genera, the same as those already mentioned in E. C. vol. ii. col. 199, viz., *Jacare*, *Caiman*, *Alligator*; but Dr. Gray has a number of smaller groups, which we presume are sub-genera. Dr. Gray also arranges the genera into larger groups intermediate in value between the family and genus. We append his definition of these groups and genera, and the generic definitions proposed by Professor Huxley are added for comparison.

I. The ventral scutella, like the dorsal ones, bony and articulated together, forming a shield. The eyelids with an internal bony plate. The cervical scutella in pairs, forming an elongated shield. Nasal bones short.

Genus 1. *Jacare.*—Head moderately high, shelving on the sides. Orbits united by a distinct bony cross ridge. Eyelids striated or rugose, strengthened by a small internal bone. The cervical scutella in four or five pairs, forming a shield; the dorsal and ventral scutella both consolidated together, forming a dorsal and ventral shield. The gular and ventral scutella smooth. The pits in the maxilla are the cavities left by the pre-orbital ridges as they advance. The intermaxillary bone short, truncated behind, with an elongate, oval, or lanceolate cavity between this and the front of the palate (Gray). The snout is broad, and rounded at the end. Each pre-frontal bone is traversed close to its anterior extremity by the ends of a strong transverse ridge, which then curves round and passes forwards on the lachrymal and maxillary bones, to subside opposite the ninth tooth. The anterior nasal aperture is not divided by bone. The vomers, separated by a longitudinal suture, appear in the palate between the pre-maxillaries and the palatine plates of the maxillaries. The temporal fossæ, though not large, are open. The webs of the feet are small. The dorsal scutes are articulated together as in the succeeding genus; and there are similarly articulated ventral scutes. There are 18—20 teeth on each side, above and below; and the fourth tooth in the upper jaw is the largest. The mandibular symphysis extends back nearly to the fifth tooth (Huxley). Dr. Gray recognises 7 species, bearing the specific names of *nigra, latirostris, multiscutata, longiscutata, ocellata, punctulata*, and *hirticollis*.

Genus 2. *Caiman*.—Head high, flattened on the sides, angulated above. Orbits without any ridges. The eyelids smooth, strengthened with a large, single, internal, bony plate. The dorsal and ventral scutella bony, articulated together, forming a dorsal and ventral shield. The gular and lateral ventral plates keeled, the abdominal ones smooth; the cervical scutella four or five pairs, with sometimes one or a pair interposed between the second and third pairs. Skull with the superior temporal fossæ obliterated, the circumjacent bones uniting, the eyelid with a single large bony plate covering the whole upper surface. Vomer not apparent on the palate (Gray). Dental formula $\frac{20-20}{22-22}$, according to Natterer. The face is without median or transverse ridges, but it is sharply angulated along a line which extends from the orbits forwards along the sides of the snout. The anterior nasal aperture is undivided in the dry skull. The vomers do not appear in the palate. The supra-temporal fossæ are obliterated, the circumjacent bones uniting over them. The webs of the feet are rudimentary. The dorsal scutes are articulated together by lateral sutures and anterior and posterior facets; and there is a ventral shield, consisting of similarly articulated scutes (Huxley). There appear to be two species only known, viz., *C. trigonatus* and *C. palpebrosus*. The third species mentioned in E. C., viz., *C. gibbiceps*, is considered to be the same as *C. palpebrosus* both by Strauch and Gray.

II. The ventral scutella thin, the dorsal scutella bony and articulated together. The eyelids fleshy, smooth. The cervical scutella in pairs, separate. Nasal bone elongate, separating the nostrils.

Genus 3. *Alligator*.—Head depressed, broad, without any ridges in front of the orbit. Snout very broad, flattened, and rounded at the end; the ninth maxillary tooth the largest. The eyelids smooth, fleshy. The dorsal scutella not articulated together, in six longitudinal series; the ventral scutella thin; the gular and abdominal shields smooth; nuchal scutella one pair, small; cervical scutella three pairs, hinder smallest. Nostrils separated by a bony septum. The feet webbed. Dorsal plates in six longitudinal series; the two vertebral closer together. The sides with a short series close to the others, sometimes reduced to only one or two shields (Gray). Dental formula $\frac{20-20}{20-20}$. Ninth maxillary tooth the largest of its series. The snout is very broad, flattened, and rounded at the end. There is an indistinct longitudinal interorbital ridge; and there are two short ridges along the line of junction of the pre-frontal and lachrymal bones. The aperture of the external nares is divided into two parts by the prolongation forwards of the nasal bones. The supra-temporal fossæ are well marked and open, though not large. The vomers do not appear in the palate. The feet are well webbed. The dorsal bony scutes are not articulated together, and there are no ventral scutes (Huxley). There is but one species, *A. mississippensis*, but specimens of this fall into two groups, one distinguished by a broader snout than the other. A similar difference is met with in several other crocodilian species, so that it not unlikely marks the two sexes, and not two varieties.

In the above synopses there will be noticed several discrepancies between the statements of the two authorities, some of which are apparent only, while others are real. It is not our purpose to attempt to reconcile these, but we may mention one in their definition of *Crocodilidæ*. Professor Huxley says the tenth tooth is the largest in the upper jaw, and Dr. Gray the ninth; but they appear to mean the same tooth. In young individuals there are eighteen teeth in the upper jaw, one of the foremost of which is deciduous. In the young the tenth is the largest tooth, but by the falling out of one of the teeth the tenth becomes the ninth in the adult. Strictly speaking it should be called the tenth, allowance being made for that which is deciduous. The above-mentioned authors have numerous other details for which we have no space, and for which the reader is referred to their memoirs. Thus Professor Huxley has a minute account of the form and arrangement of the scutes, in which he points out their peculiarities in the various genera, and indicates those species which have them on the ventral surface. This last feature was generally supposed to be restricted to the extinct species until Professor Huxley drew attention to their presence in living forms. Their oversight by previous observers appears to have been in great part due to the practice of fixing down the specimens in museums so that the underside can only be seen with great difficulty and inconvenience. In Dr. Gray's paper, which is richly illustrated, full details are given of the synonymy of the group. He also gives a summary of the geographical distribution of the species, which we quote. The *Gavialidæ* are confined to Asia and Australasia. The *Crocodilidæ* are found in all quarters of the globe except Europe, but each division has certain genera restricted to it. Thus *Crocodilus, Halcrosia*, and *Mecistops*, are confined to Africa; *Oopholis* and *Bombifrons* to Asia and Australasia; and *Palinia* and *Molinia* to America. The *Alligatoridæ* occur in America only.

"In Africa there are three species of crocodiles. They seem all to have been known to Adanson. They are: (1) the common crocodile (called the olive crocodile by Adanson), *Crocodilus vulgaris*, which is spread over the whole of Africa, from north to south, and from east to west; (2) the black crocodile of Adanson, *Halcrosia nigra*; and (3) the false gavial of Adanson, *Mecistops cataphractus*. The two latter are confined to the rivers on the west coast of Africa. In India there are three species of crocodiles: (1) the *Oopholis porosus* (or *Crocodilus biporcatus* of Cuvier) which is found only in the estuaries at the mouths of large rivers; (2) the Muggar, or more properly the Coombeer (*Bombifrons indicus*); and (3) the Gavial or Ghurrial, which is confined to the rivers in the interior of the country. The Coombeer or Muggar ascends the rivers to the mountains, where the water is often frozen. The Ghurrial, on the contrary, is confined to the lower level, where the climate is warm. In stating that there are three species of crocodiles in India I only intend to state there are three distinct forms; for I will not undertake to say for certain that the Muggar of Ceylon, of Siam, and of India, are not distinct species. Mr. Blyth observes, 'Both the Gangetic species have been received by the Asiatic Society, Calcutta, from Java. The crocodiles are known to abound in Timor, from which island they may well have passed to Australia. Governor Grey met with them in the north-west.' 'Rep. Austral. Vert. in Mus. A. S. C.' If by both the Gangetic species of crocodile Mr. Blyth means the estuarine crocodile (*Oopholis porosus*) and the Coombeer or Muggar (*Bombifrons indicus*), no example of the latter animal from either Java, Timor, or Australia, has occurred to me, and the animal figured as *Crocodilus raninus* by Dr. Solomon Muller is certainly *Oopholis porosus;* and there is in the British Museum a fine adult skull of that species sent by the Leyden Museum from Java. The observations of MM. Duméril and Bibron (Erp. Gen. 25, 47), that crocodiles are not found in Australia, and that the American crocodiles are confined to the islands of that continent, are no longer consistent with facts; indeed, long before the publication of their work various travellers had recorded the occurrence of crocodiles on the north coast of Australia. The estuarine *Oopholis porosus* was observed by Governor Grey on the north-west coast of Australia. There is in the British Museum a skull of the species sent thence, and also a full grown specimen which was killed and preserved in that country. The island of Borneo is inhabited by a false gavial, named *Tomistoma Schlegelii*. I am not aware that it has been found in any of the other islands of the Archipelago. It is intermediate in character between the true gavial and the crocodile. The crocodiles and alligators are widely distributed in America. There are four American crocodiles and nine alligators. One of the crocodiles, *Palinia rhombifer*, is peculiar to the island of Cuba. The other species of crocodiles and alligators are found on the mainland. The *Alligator mississippensis* is found far north, where the waters are often frozen; all the other alligators and American crocodiles are confined to the tropical and subtropical parts of the continent. *Molinia americana* is found in Cuba and St. Domingo as well as in the rivers of the east and west side of the continent, showing the incorrectness of the assertion of MM. Duméril and Bibron, that the crocodiles of America are confined to the islands of that continent (Erp. Gen. 25, 47)."

Much might be said respecting the special anatomy of the group, but for such details the reader should consult the work by Bruhl, entitled 'Icones ad Zootomiam illustrandum, Das Skelet der Krokodolinen,' published in 1862, to which a supplementary part, on the ear bones, was added in 1865. There is also a great mass of information in Rathke's 'Untersuchungen über die Entwickelung und die Korperbau des Krokodile,' published in 1866. There are two excellent myological articles, the one on the muscles of the alligator, by Hair, in the 'Journal of Anatomy and Physiology' for 1867, pp. 26—41; and the other on the muscles of the crocodile's leg, by Haughton, in the 'Annals and Magazine of Natural History,' 3rd series, xvi., pp. 326—331. There are numerous scattered notices on the structure of these creatures in more general works, such as Professor Owen's 'Anatomy of Vertebrates,' vol. i. There is another large and important branch of our subject, of which nothing has been said, although there is no lack of materials; we allude to the species which have passed away. There are numerous scattered notices respecting them, but we have not met with any recent connected account. The most important paper we know is that by Deslongchamps, in the 'Mémoires de la Société Linnéenne de Normandie,' tome xiii., having for title 'Premier mémoire contenant l'exposé des caractères généraux des Téléosauriens comparés a ceux des crocodiliens, &c.' We should also mention that the classificatory paper by Strauch, to which allusion was made in the early part of this article, will be found in vol. x. of the Memoirs of the Academy of Science at St. Petersburg. (Gray, J. E., *Transactions of the Zoological Society*, vol. vi., p. 125; Huxley, T. H., *Journal of the Proceedings of the Linnean Society*, vol. iv., pp. 1—28.)

CROCODILIDÆ. [CROCODILIA, E. C. S.]

CRUSTACEA [E. C. vol. ii. cols. 217—235]. Many new facts have been acquired by science during the last twenty or thirty years bearing upon the structure and development of this class of beings, upon each of which subjects we propose to offer a few supplementary details.

So far as we know, no full account has been published of the integumental or outer membranes of all the crustacean orders, whereby we might trace the variations which this part of the organism undergoes in the various groups. In the Decapoda, or rather in all that have been yet examined, there may be recognised six distinct layers differing from each other in structure. These we will notice in the order of their superposition, beginning with the outermost and proceeding downwards to the innermost. (1) The most external layer is generally thin, and has few or no traces of structure. It is the 'horny structureless layer' of Dr. Carpenter, and the 'pellicle' or 'pellicular layer' of Professor Williamson. Although said to be horny, it is probable that this expression refers to the appearance only, since, chemically, it is more calcareous than any of the other layers. In some species, as, for instance, *Hyas araneus*, it is more or less deeply coloured, and shows signs of structure in being built of numerous thin layers. The thickness of this pellicle varies in the different species, being exceedingly thin, relatively to the others, in the lobster and cray fish, and of considerable proportions in *Pilumnus hirtellus*. It is sometimes traversed by minute canals or tubules, which will be again alluded to in connection with another layer. (2) The second or areolated layer is frequently said to be of a cellular structure; but the existence of cells is very doubtful. When viewed from above the layer is seen to be covered with minute dots, arranged in groups approaching more or less perfectly to hexagons, the groups being separated by narrow non-areolated lines. When viewed vertically the layer appears to have a horizontally laminated structure, and to be traversed by minute tubules filled with air. The dots on the surface are evidently the apertures of the tubules. In some species, as the crayfish, the layer has a uniform thickness, and the tubules are always vertical, that is, at right angles to the lay of the laminæ. In other species, such as the common crab and the hermit crab, the layer is irregular in thickness, owing to ridges of the underlying layer being projected through so as to touch, or nearly touch, the pellicle. In the vertical section the areolated layer appears to occupy valleys in the third layer, or calcified corium, and the laminæ curve upwards as they approach the bounding ridges; but the tubules still retain their position at right angles to the lay of the laminæ. This disposition Professor Williamson conceives will explain the radiated cells observed by Quekett near the ridges, as this sort of radiated appearance results from the inclined arrangement of the tubules at those parts. Similar appearances occur in the shrimp, but owing to the minuteness of the areolæ and tubules it is difficult to demonstrate their true nature. Professor Williamson says he has seen air in some of the lines, and, from their analogy with those of the crab, infers they are tubular in that species. Other observers have not been able to detect air, and hence they maintain that the lines are solid fibrillæ, and the areolæ are termed granules, being considered to be the termination of solid rods and not the apertures of minute canals. In *Hyas araneus* the areolated layer presents another mode of arrangement. In the vertical section it resembles a series of conical masses somewhat like round-topped sugar loaves. The flat bases are lowermost, while the rounded tops project upwards. In the horizontal aspect these masses have a prismatic outline; and from the two views together it is seen that the interspace between the summits of the masses is filled up with the pellicle, and that these depressions correspond with the non-areolated lines which separate the hexagonal groups of areolæ. In the lobster the colour resides in the areolated layer. (3) The third layer answers to the laminated tubular substance of Dr. Carpenter, and the calcified corium of Professor Williamson. In the crayfish its upper and lower surfaces are parallel, and its thickness differs but little from that of the areolated layer above. In the common crab its upper surface forms, as already stated, a series of steep-sided, flat-topped ridges, which project through the areolated layer. It is tubulated, and the tubuli are continuous with those which pass through the underlying and overlying portions of the integument. At the ridges it forms nearly the entire thickness of the skin, and under the valleys about three-fourths. In the claw of the hermit crab its upper surface forms rounded prominences which abut upon the pellicle to the exclusion of the areolated layers, and from the summits of the protuberances tubules pass through the pellicle. This feature is also met with in the crab. In the hermit crab's claw the thickness of this layer is considerable; it forms five-sixths of the integument. In *Pilumnus hirtellus* it has quite another arrangement from those already noticed. The upper surface is even, and the under surface is highly undulated, the undulations being alternately large and small. It presents two different kinds of calcification. The portion which is calcified in one way occupies circular depressions in the fourth layer, and forms the larger undulations. In the vertical section it forms basin-shaped masses separated from one another by the portion which is calcified differently, and which forms the smaller undulations. The centre of each basin is penetrated by a large vertical canal, which passes downwards through the underlying structures, and terminates upwards with the base of a hair, with the interior of which it is in communication. The base of the hair rests upon the upper surface of this layer. In a horizontal section the calcified corium shows numerous circular areas with a central dot, and thus simulates a cellular structure. The central dot is the large canal, not a nucleus, and the area is a calcareous concretion, not a cell. The thickness of this layer varies from one-third to one-half that of the integument. (4) The calcified corium rests upon a layer which resembles the corium in most respects, but differs from it in showing little or no calcification. It can be readily separated from the hard shelly part, and is usually a very thin membrane of uniform thickness. In *Pilumnus hirtellus* it is as thick as any of the other layers, and like them is richly tubulated, or if the existence of tubules be denied, richly fibrillated. (5) This is a thin delicate membrane, which Williamson calls the basement membrane. (6) Underlying all is the true endoderm, which is at once distinguishable by its indubitably cellular structure, and the absence of tubulations or fibrillations. Little appears to be known as to the growth and mode of development of these various layers. In the soft parts of the hermit crab there is a well developed derm, or basement membrane, and a pellicle. The intermediate layers are scarcely perceptible, but in the vicinities of the hard parts they are represented by a thin granulated membrane, which acquires an areolated structure where it thickens, and presents indistinct traces of an hexagonal arrangement of the areolæ. Professor Williamson's views as to the genesis of the skin of crustaceans are thus expressed by him: "It is clear that no cells exist external to the basement membrane; they all underlie it. Whether or not the basement membrane is cast off along with the exuviated shell has not yet been determined, but probably such is not the case. The cellular derm appears to be the secreting organ producing the tegument, which latter permeates the basement membrane by exosmosis when in a fluid state, and becomes consolidated into a structureless layer external to the membrane. The laminæ first formed are apparently those constituting the pellicle, then those constituting the areolar layer, and subsequently those forming the corium. Calcification of these layers, both in its primary and secondary varieties, is a process occurring subsequently to the formation of the membranous lamellæ, and probably due to some protoplasmic fluid conveyed into the tissues by means of the tubuli with which they abound. Prior to the formation of these laminæ, some of the cells of the derm or enderon change their form and position. The tubuli themselves probably exist as such prior to calcification; the latter only rendering them more distinct. . . . . . We are thus compelled, equally from an examination of their mature states, and from their development as traced in the hermit crab, to reject Dr. Carpenter's hypothesis of the cellular structure of the areolated layers of crustacean integuments. At the same time they illustrate how a cellular protoplasmic structure may secrete a tubular tissue closely resembling dentine, from which it is separated by a structureless basement membrane, through which neither cells nor nuclei ever pass. Whether the cells have anything to do with determining the position of the areolæ in the calcified layers I cannot say, though I doubt their doing even that much, since the spaces they occupy do not seem to correspond with those of the areolæ; nevertheless, the question is worth further investigation could crustacea that have just moulted be obtained for examination." The process of moulting, or ecdysis, has been observed within the last few years in several species of crustacea; but the cases on record are not numerous, since it is far more difficult to watch the operation in its various stages than to assure oneself that the process is effected. The lobster selects a suitable spot, and remains rigidly still for from forty to fifty hours, when a crack commences at the first abdominal ring and extends to the carapace. The creature then agitates itself violently, and by this means manages to protrude a portion of the first abdominal ring through the crevice. It next rests for a while, and then by renewed efforts forces more and more of the abdominal portion of the body out of the shell; other periods of rest and action follow, until the whole of the abdomen is liberated through the same short narrow fissure which sufficed for the extrication of the first segment. The carapace next splits as far forwards as the rostrum, and the space between its hindmost edge and the first abdominal ring of the shell is increased as much as possible. The liberation of the fore part of the body is effected by successive steps, the hindmost portions being extricated first. The legs are withdrawn in the order of their position, and although each pair are released without much effort, there are as many periods of rest as there are pairs of legs. Greater difficulty is experienced with the large claws, which are pulled with such powerful and sudden tugs that the muscles are wiredrawn in their passage through the narrow joint of the old shell. The shell of the hard chelæ is not split or disarticulated. The whole process lasts for about half an hour. The lobster now appears in a highly elongated condition; it gradually becomes shorter, but much larger, owing, as is believed, to distension of its tissues with water. In another week or a fortnight, the time being much influenced by the temperature, the new shell has become calcified and hardened.

In comparing this account with that given in E. C. vol. ii. col. 220, it will be noticed that the lobster and crayfish present several differences in their modes of casting off the old shell. In the crayfish the cephalothorax is liberated before the abdomen, while the reverse is the case with the lobster. The lobster splits the carapace, while the crayfish leaves it unsplit. According to Réaumur, the hard chelæ are split longitudinally; but this assertion is questioned by some authorities, since no crack can be detected in this part in the moulted shells. The lobster has much smaller wrist joints, and yet it contrives to withdraw the soft chelæ without fracturing the hard chelæ. The crayfish leaves its moulted shell resting on its dorsal surface, but the lobster's slough remains on its ventral surface.

The heart, in *Astacus*, is a muscular organ formed by an intricate interlacement of fibres. It has great pulsatile force, but little is known as to the nerves connected with it. Its action does not primarily depend upon the principal ganglion, since the destruction of that nervous centre causes a temporary cessation only in its action. It continues to beat when withdrawn from the body, as also when cut in two, and even the pieces formed by its further division retain their activity for a more or less considerable space of time. In its behaviour towards chemical and physical agents and stimulants it behaves like the muscles of vertebrates, and in its structure it is intermediate between the ordinary muscles and the heart of the same subkingdom of animals.

The principal recent memoir on the sense of hearing in crustacea is that by Dr. Hensen. He endeavoured to ascertain whether these creatures could appreciate sounds, and having satisfied himself upon that point, he experimented with a view to ascertaining the nature and disposition of the auditory organs. Ordinarily the crustaceans in aquaria showed no indications that they could appreciate sounds made in the surrounding air; but when a peculiar sound was made in the air, and the vibrations were communicated to a membrane floating on the water, the creatures would jump. A repetition of the noise seldom had the same effect as the first, probably, as Dr. Hensen suggests, because the animals controlled their movements, and not because they did not appreciate the noise. Some species seemed to be more sensitive than others. Thus a young *Palæmon antennarius* jumped out of the water when the floor or sides of the vessel were struck noisily, although it took no notice of the shaking of the aquarium when no noise accompanied the movement. The sense of hearing appears to be heightened to a remarkable degree when a little strychnine is added to the water. Then the animals respond by jumping to every sound that occurs in the house, but no effect is produced by shaking the vessel or laying hold of the outer antennæ. If a sound be made when the creature is suspended by its outer antennæ it makes violent efforts to escape, and on being freed, sinks to the bottom in a highly convulsed state. Restoration to sea water without strychnine soon brings it back to its normal condition. *Mysis spinulosus* is very excitable under the influence of sound. Dr. Hensen believes that the auditory organ consists of an auditory chamber, which may or may not contain otoliths, and which is usually connected with a special kind of hair, which he terms auditory hairs. These hairs, he conceives, play an important part in enabling the animal to appreciate and discriminate sound, since, as he believes, each hair is adapted to its own peculiar sound, vibrating only when that sound is produced. He contrived an apparatus whereby he could observe these hairs through a microscope when under the influence of sound. In this way he ascertained that when a note was sounded some hairs vibrated strongly, the vibration lasting as long only as the note was continued. On trying another, other hairs vibrated, while those which were previously active either remained still or did not vibrate strongly. These hairs have various positions. Sometimes they are implanted on the otoliths themselves, sometimes they occur on the inner surface of the auditory chamber, and sometimes they are situated on external parts, such as the antennæ. Dr. Hensen classifies the different kinds of auditory apparatus in four divisions, as follows:—(1) An open auditory chamber containing one otolith only, as in *Lucifer*, *Sergestes*, *Mysis*, *Hippolyte*, *Mastigopus*. (2) An open chamber with several otoliths, as in *Palæmon*, *Pasiphaë*, *Crangon*, *Alpheus*, *Astacus*, *Gebia*, *Pagurus*, *Palinurus*, *Nephrops*, *Lithodes*. (3) A closed auditory chamber without otoliths, as in *Porcellana* (?). *Hippa*, *Pinnotheres*, *Myctiris*, *Ocypoda*, *Grapsus*, *Nautilograpsus*, *Sesarma*, *Lupea*, *Platycarcinus*, *Pilumnus*, *Chlorodius*, *Gelasimus*, *Trapezia*, *Carcinus*, *Hyas*. (4) Auditory chamber and otoliths absent, as in *Alima*, *Erichthus*, *Phyllosoma*, *Thysanopoda*, and *Pandalus*.

Amongst crustaceans the individual undergoes a series of remarkable changes of form in developing from the egg to maturity; changes which are as striking as any to be found in the most polymorphic classes. Some reference is made to these changes in E. C., and we would add here a few more remarks.

Most of the species of stalk-eyed crustaceans (*Podophthalmia*) whose life history has been traced quit the egg in the *Zoëa* form, of which a minute account has been given in E. C., the example selected being that of the common shore crab. The exceptions are restricted to those species which live either in fresh water or on the land, but it is not all these which undergo no metamorphosis. Most of the *Zoëæ* have a general resemblance to that of the shore crab. They have a moderately sized carapace, a segmented tail without appendages, while the middle or thoracic portion of the body, with its five pairs of limbs, is absent or rudimentary. There are no branchiæ or special organs of respiration, the breathing function being performed by the skin generally, but more especially those parts of it underlying the lateral parts of the carapace, since a constant current of water enters at the hinder margin of the carapace and passes forward. There are two or three pairs of natatory limbs which belong to the cephalic portion of the body, but which are afterwards converted into organs connected with the mouth. The eyes are sessile and paired. In the *Brachyura* the carapace is more or less armed with spiny processes, of which one springs from the back, a second projects as a beak, while two others constitute the projections at the posterior lateral portions of the carapace. In the *Canceridæ* the tail of the *Zoëa* form is variable in contour, but always supports three pairs of setæ. In *Porcellana* and allied genera the tail bears five pairs of setæ; the dorsal spine is small, but those on the front and sides are of extraordinary dimensions. The *Palinuridæ*, which are generally admitted to belong to the Podophthalmian group, have a mode of development quite exceptional to the group, but frequently found amongst the *Edriophthalmia* or sessile eyed crustacea. The young quit the egg with an unsegmented ovate body, a single eye placed in front, and three pairs of natatory feet. It has no carapace, no paired eyes, no masticating organ, such as are found in the *Zoëa* form; it corresponds to what is known as the *Nauplius* form. By the demarcation of the cephalic from the abdominal part of the body, by the development of mouth organs, and by other modifications, it somewhat approaches the *Zoëa* form, although it still differs from it in several important details of its internal structure. At a later stage it acquires a pair of large sessile eyes, the middle body or thorax and abdomen become segmented, and other important changes occur which convert it into the *Mysis* or Schizopod form. On this stage F. Müller makes the following remarks:—"The antennæ cease to serve for locomotion, their place is taken by the thoracic feet furnished with long setæ, and by the long abdomen which just before was laboriously dragged along as a useless burden; but now, with its powerful muscles, jerks the animal through the water in a series of lively jumps. The anterior antennæ have lost their long setæ, and by the side of the last (fourth) joint, endowed with olfactory filaments, there appears a second branch which is at first of a single joint. The previously multiarticulate outer branch of the posterior antennæ has become a simple lamella, the antennal scale of the prawn; beside this appears the stump-like rudiment of the flagellum, probably as a new formation, the inner branch disappearing entirely. The five new pairs of feet are biramose, the inner branch short and simple, the outer one longer, annulated at the end, furnished with long setæ, and kept, as in *Mysis*, in constant whirling motion. The heart acquires new fissures and interior muscular trabeculæ. During the *Mysis* period the auditory organs in the basal joint of the anterior antennæ are formed; the inner branches of the first three pairs of feet are developed into chelæ, and the two hinder pairs into ambulatory feet; palpi sprout from the mandibles, branchiæ on the thorax, and natatory feet on the abdomen. The spine on the labrum becomes reduced in size. In this way the animal gradually approaches the prawn form, in which the median eye has become indistinct, the spine of the labrum and the outer branches of the cheliferous and ambulatory feet have been lost, the mandibular palpi and the abdominal feet have acquired distinct joints and setæ, and the branchiæ come into action." Another exception is presented by *Mysis* itself, which was formerly placed amongst the *Stomapoda* [STOMAPODA, E. C. vol. iv. col. 905]. The embryo is dorsally concave when in the egg, whereas the embryos of most crustaceans are so bent that the ventral surfaces are approximated. The first part which appears is the tail, then long appendages from the fore part of the body, followed by rudiments of the antennæ and mandible, and the skin. There are no internal organs when the embryo leaves the egg. According to Müller, the animal at this stage conforms to the *Nauplius* type of structure, and afterwards a larva, which has essentially the grade of a *Zoëa*, is developed within the *Nauplius* skin.

The sessile-eyed crustaceans or *Edriophthalmia* have a less varied developmental history than the stalk-eyed group. In the Isopods the embryo is usually, perhaps always, bent upwards, so that what is exceptional amongst the Decapods is normal in this order. *Ligia* and other Isopod genera also resemble *Mysis*, in that a larval membrane representing the *Nauplius* stage is first formed, within which the embryo Isopod is partially developed. The embryo differs little from the mature form when it leaves the membrane; the principal differences are that there are six, not seven, pairs of ambulatory feet, and that the sexual peculiarities are not developed. We may here notice what may be regarded by some as a remarkable exception to the usual mode of development amongst Isopods, viz., the statement by M. Hesse, that *Praniza* is the larval form of *Anceus*. M. Hesse has applied the name *Praniza* to the larvæ of *Anceus*, but these larvæ do not answer to what Montagu, the founder of the genus, called *Praniza*. The forms which he so called are really adult females, whose corresponding males constitute the genus *Anceus*. In this order there are numerous examples of a remarkable phenomenon, viz., retrograde metamorphosis, that is, a metamorphosis in which the young become less, not more, differentiated in structure. This kind of metamorphosis is connected with an adaptation of these beings for a special kind of life. "Even in some Fish-lice (*Cymothoa*) the young are lively swimmers, and the adults stiff, stupid, heavy fellows, whose short clinging feet are capable of but little movement. In the *Bopyridæ* (*Bopyrus*, *Phryxus*, *Kepone*, &c., which might have been conveniently left in a single genus), which are parasitic on crabs, lobsters, &c., taking up their abode chiefly in the branchial cavity, the adult females are usually quite destitute of eyes; the antennæ are rudimentary; the broad body is frequently unsymmetrically developed in consequence of the confined space; its segments are more or less amalgamated with each other; the feet are stunted, and the appendages of the abdomen transformed from natatory feet with long setæ into foliaceous or tongue-shaped and sometimes ramified branchiæ. In the dwartish males the eyes, antennæ, and feet are usually better preserved than in the females; but, on the other hand, all the appendages of the abdomen have not unfrequently disappeared, and sometimes every trace of segmentation. In the females of *Entoniscus*, which are found in the body cavity of crabs and *Porcellanæ*, the eyes, antennæ, and buccal organs, the segmentations of the vermiform body, and in one species (*Entoniscus cancrorum*) the whole of the limbs disappear, almost without leaving a trace; and *Cryptoniscus planaroides* would almost be regarded as a Flat-worm rather than an Isopod, if its eggs and young did not betray its crustacean nature. Among the males of these various *Bopyridæ*, that of *Entoniscus porcellanæ* occupies the lowest place; it is confined all its life to six pairs of feet, which are reduced to shapeless rounded lumps" (Müller's 'Facts for Darwin,' translated by Dallas, p. 73). In *Amphipoda* the embryos are bent downwards, and when they leave the egg have a general resemblance to their parents.

The *Phyllopoda*, with but few exceptions, pass through the *Nauplius* and *Zoëa* stages, either as embryos or as free larvæ, and in the mature form appear to be but slightly modified *Zoëæ*. The *Copepoda* also commence active life in the *Nauplius* form, and undergo various changes, as expressed by Müller in the following passage. "All the larvæ of the free *Copepoda* investigated by Claus have, at the earliest period, three pairs of limbs (the future antennæ and mandibles), the anterior with a single and the two following ones with a double series of joints or branchiæ. The unpaired eye, labrum, and mouth already occupy their permanent positions. The posterior portion, which is usually short and destitute of limbs, bears two terminal setæ, between which the anus is situated. The form in this *Nauplius* brood is extremely various; it is sometimes compressed laterally, sometimes flat, sometimes elongated, sometimes oval, sometimes round or even broader than long, and so forth. The changes which the first larval stages undergo during the progress of growth consist essentially in an extension of the body and the sprouting forth of new limbs. The fourth stage already displays a fourth pair of extremities, the future maxillæ. Then follow at once three new pairs of limbs (the maxillipedes and the two anterior pairs of natatory feet. The larva still continues like a *Nauplius*, as the three anterior pairs represent rowing feet; at the next moult it is converted into the youngest *Cyclops*-like state, when it resembles the adult animal in the structure of the antennæ and buccal organs, although the number of limbs and body segments is still much less, for only the rudiments of the third and fourth pairs of natatory feet have made their appearance in the form of cushions fringed with setæ, and the body consists of the oval cephalothorax, the second, third and fourth thoracic segments, and an elongated terminal joint. In the *Cyclopidæ* the posterior antennæ have lost their secondary branch, and the mandibles have completely thrown off the previously existing natatory feet, whilst in other families those appendages are present, more or less altered. Beyond this stage of free development many forms of the parasitic *Copepoda*, such as *Lernanthropus* and *Chondracanthus*, do not pass, as they do not acquire the third and fourth pairs of limbs, nor does a separation of the fifth thoracic segment from the abdomen take place; others (*Achtheres*) even fall to a lower grade by the subsequent loss of the two pairs of natatory feet. But all free *Copepoda*, and most of the parasitic crustacea, pass through a longer or shorter series of stages of development, in which the limbs acquire a higher degree of division into joints in continuous sequence, the posterior pairs of feet are developed, and the last thoracic segment and the different abdominal segments are successively separated from the common terminal portion." (l. c. p. 85.) In the *Cirripedia* and *Suctoria* the embryos commence free life in the *Nauplius* form, but differ from the corresponding stage in the prawns and copepods in that they have a dorsal shield, and that certain peculiar filaments, termed olfactory filaments, spring directly from the principal ganglion, and not from the anterior antennæ. While, however, the young of *Suctoria* and *Cirripedia* agree in some essential points, they differ in others. The Suctorian larva has an abdomen which terminates in two short points, while in the Cirripedian larva the same part is continued as a long furcate tail. The young Cirripede possesses a mouth, stomach, intestine, anus, and two posterior pairs of limbs, provided with teeth, setæ, and hooks, which are used for securing the food; but the young Suctorian has none of these. The astomatous Suctorian, not being adapted for a long continuance in this state, soon passes into a second stage, to which Darwin has given the name 'pupæ.' These have a folded carapace and the general appearance of a *Cypris*. The *Nauplius* of the *Cirripedia* has a longer existence as such, and undergoes several moults before it assumes the *Cypris* form. In this state the two orders more resemble each other than in the previous state, but the Cirripedes are distinguished by having a pair of compound eyes, which are not present in the Suctorians. The *Cypris* forms of both orders attach themselves to foreign bodies by means of their adherent feet; those of the Cirripedes select hard materials, such as rocks, shells, the carapace of turtles, wood, &c., while those of *Suctoria* select soft bodies, such as the abdomens of various *Crustacea*. The Cirripedes form a peculiar testaceous covering, and their feet are modified into vibratile organs which drive currents of water through the mouth. The *Suctoria* remain without a mouth, lose all their limbs, and develope from their point of attachment a complicated tubular system which is rooted in the substance of their hosts, and through which they pump up the animal fluids from which they derive their support. In some species of *Suctoria* the individual leaves the egg in the pupa or *Cypris* form, without passing through the *Nauplius* stage.

Such is a summary of the curious developmental changes in this class of beings. Why should the young differ from the adults? why should there be a general resemblance between the very young individuals of the same age belonging to the same order? and yet why should a few species differ from their nearest allies in mode of development? These, and a hundred other questions might be asked—but can we find the space in which to answer them? Some are answered in F. Müller's book which we have already quoted, and to it we would refer the reader. The above-mentioned author discusses how far the facts support the received views as to the value of the characters of the transition states for purposes of classification, the Darwinian theory, and the idea that the changes of form in the individual exemplify the changes of form which the order or class has slowly undergone during the distant eras of the past. According to some authorities the individuals of a class commence with being absolutely identical, as in the egg stage. They then travel together in unison for a certain period, when some diverge and follow a different course of development; further changes ensue, and other divergencies follow, so that a greater and greater amount of differentiation takes place. On this view it is stated that the more nearly allied two species are for so much the longer period do they continue to be undistinguishable. And it is further stated that the importance of the parts is regulated by the order in which they are developed. F. Müller entirely dissents from all this. His view, stated as briefly as possible, seems to be that while the species belonging to the same natural group resemble each other in their mode of development, yet that they present variations at every stage of their development. These variations have been induced upon the same principles as have brought about variation in the adult forms. The larval changes, then, represent two sets of variations, which we will designate, for convenience, as primary and secondary. The primary set represent the hereditary transmission of the changes which have taken place in adult forms; the secondary those which have been acquired by the larvæ while in the larval condition, and which are also passed on from generation to generation in an unaltered or modified form. We have no room for examples, but one must suffice. The *Cirripedia* and *Suctoria* leave the egg in the *Nauplius* form. The *Nauplii* present considerable differences amongst themselves, but these are lessened, not increased, when they change from *Nauplii* into the *Cypris* form. On exchanging the last state for the mature condition, they again follow widely different courses of development. He conceives that the *Nauplii* have undergone more variation than the *Cypris* form, and hence he would probably admit that some of the characters of the *Nauplii* are of more recent origin than the first appearance of the mature form as at present known. It might be inferred that the *Nauplii* of, say, palæozoic times, if they were known, differed from those of the present day by characters which in a classificatory scheme would have a specific, generic, or even ordinal value. Dr. Müller devotes several chapters to a consideration of the evolution of crustaceans from a Darwinian point of view, and in order to show the general tenor of his ideas, we quote the following passage:—"It would be easy to weave together the separate threads furnished by the young forms of the various *Crustacea* into a general picture of the primitive history of this class. Such a picture, drawn with a little skill and finished in lively colours, would certainly be more attractive than the dry discussions which I have tacked on to the developmental history of these animals. But the mode of weaving in the loose threads would still in many cases be arbitrary, and to be effected with equal justice in various ways; and many gaps would still have to be filled up by means of more or less bold assumptions. Those who have not wandered much in this region of research would then readily believe that they were standing upon firm ground where mere fancy had thrown an airy bridge; those acquainted with the subject, on the other hand, would soon find out these weak points in the structure, but would then be easily led to regard even what was founded upon well-considered facts as merely floating in the air. To obviate these conceptions of its true contents from either side, it would be necessary to accompany such a picture throughout with lengthy dry explanations. This has deterred me from further filling in the outline which I had already sketched. I will only give as an example the probable history of the production of a single group of *Crustacea*, and indeed of the most abnormal of all, the *Rhizocephala* (embracing most of the parasitic forms, such as *Caligus*, *Lernæa*, &c.), which in the sexually mature form differ so enormously even from their nearest allies, *Cirripedia*, and from their peculiar mode of nourishment stand quite alone in the entire animal kingdom. I must preface this with a few words upon the homology of the roots of the *Rhizocephala*, *i.e.*, the tubules which penetrate from its point of adhesion into the body of the host, ramify amongst the viscera of the latter, and terminate in cæcal branchlets. In the pupæ of the *Rhizocephala* the foremost limbs (prehensile antennæ) bear, on each of the two terminal joints, a tongue-like, thin-skinned appendage, in which we may generally observe a few small strongly refractive granules, like those seen in the roots of the adult animals. I have therefore supposed these appendages to be the rudiments of the future roots. A perfectly similar appendage, 'a most delicate tube or ribbon,' was found by Darwin in free swimming pupæ of *Lepas australis* on the last joints of the prehensile antennæ. From the perfect accordance in their entire structure shown by the pupæ of the *Rhizocephala* and *Cirripedia*, there can be no doubt that the appendages of *Sacculina* and *Lepas* which are so like each other and spring from the same spot, are homologous structures. Now in these species of *Lepas*, in *Dichelaspis Warwickii* and in *Scalpellum Peronii*, Darwin saw, on tearing recently affixed animals from their point of support, that a long narrow band issued from the same point of the antennæ; its end was torn away, and in *Dichelaspis*, judging from its ragged appearance, it had attached itself firmly to the support. From this it follows that this appendage in *Lepas australis* can hardly be anything but a young cement duct. If, therefore, the supposition that the appendages on the antennæ of the pupæ of *Rhizocephala* are young roots be correct, the roots of the *Rhizocephala* are homologous with the cement ducts of the *Cirripedia*. And this, strange as it may seem at first sight, seems to me scarcely doubtful. It is true that the act of adhesion of the *Rhizocephala* has never been observed, but it is more than probable that they attach themselves, just like the *Cirripedia*, by means of the antennæ, and that, therefore, the points of attachment in the two groups indicate homologous parts of the body. From the point of attachment in the *Rhizocephala* the roots penetrate into the body of the host, whilst in the *Cirripedia* the cement ducts issue from the same point. The roots are blind tubes, ramified in different ways in different species. The cement ducts in the basis of the *Balanidæ* likewise constitute a generally remarkably complicated system of ramified tubes, with regard to the mode of termination of which nothing certain has yet been made out. Individual cæcal branches are not unfrequently seen even in the vicinity of the carina; and, at least in some species, in which the cement ducts divide into extremely numerous and fine branchlets, forming a network which gradually becomes denser towards the circumference of the basis, these seem nowhere to possess an orifice.

"Now as to the question: How were *Cirripedia* converted by natural selection into *Rhizocephala?* A considerable number of existing *Cirripedia* settle exclusively or chiefly upon living animals; on sponges, corals, mollusks, cetaceans, turtles, sea-snakes, sharks, crustaceans, sea-urchins, and even on acalephs. *Dichelaspis Darwinii* was found by Filippi in the branchial cavity of *Palinurus vulgaris,* and I have met with another species of the same genus in the branchial cavity of *Lupea diacantha.* The same thing may have taken place in primitive times. The supposition that certain cirripedes might once upon a time have selected the soft ventral surface of a crab, *Porcellana* or *Pagurus,* for its dwelling-place, has certainly nothing improbable about it. If, then, the cement ducts of such a cirripede, instead of merely spreading on the surface, pierced or pushed before them the soft ventral skin and penetrated to the interior of the host, this must have been beneficial to the animal, because it would be thereby more securely attached and protected from being thrown off during the moulting of its host. Variations in this direction were preserved as advantageous. But as soon as the cement ducts penetrated into the body cavity of the host, and were bathed by its fluids, an endosmotic interchange must necessarily have been set up between the materials dissolved in these fluids and in the contents of the cement ducts, and this interchange could not be without influence upon the nourishment of the parasite. The new source of nourishment opened up in this manner was, as constantly flowing, more certain than that offered by the nourishment accidentally whirled into the mouth of the sedentary animals. The individuals favoured in the development of the cement ducts, now converted into nutriferous ducts, had more than others the prospect of abundant food, of vigorous growth, and of producing a numerous progeny. With the further development, assisted by natural selection, of the roots embracing the intestine of the host and spreading among its hepatic tubes, the introduction of nourishment through the mouth and all the parts implicated in it, such as the whirling cirri, the buccal organs, and the intestine, gradually lost their importance, became absorbed by disuse, and finally disappeared without leaving a trace of their existence. Protected by the abdomen of the crab, or by the shell inhabited by the *Pagurus,* the parasite also no longer required the calcareous test, in which, no doubt, the first cirripedes settling upon these decapods rejoiced. This protective covering having become superfluous also disappeared, and there remained at last only a soft sack filled with eggs, without limbs, without mouth or alimentary canal, and nourished, like a plant, by means of roots which it pushed into the body of its host. The Cirripede had become a Rhizocephalon. If it be desired to form a notion of what our parasite may have looked like when halfway in its progress from the one form to the other, we may consult the figures given by Darwin (*Lepadidæ,* pl. iv., figs. 1—7) of *Anelasma squalicola.* This Lepadide, which lives upon sharks in the North Sea, seems, in fact, to be in the best way to lose its cirri and buccal organs in the same manner. The widely-cleft shell-less test is supported upon a thick peduncle, which is immersed in the skin of the shark. The surface of the peduncle is beset with much ramified hollow filaments, which 'penetrate the shark's flesh like roots' (Darwin). Darwin looked in vain for cement glands and cement. It seems to me hardly doubtful that the ramified hollow filaments are themselves nothing but the cement ducts converted into nutritive roots, and that it is just in consequence of the development of this new source of nourishment that the cirri and buccal organs were in the highest degree absorbed. All the parts of the mouth are extremely minute; the palpi and exterior maxillæ have almost disappeared; the cirri are thick, inarticulate, and destitute of bristles; and the muscles both of the mouth and cirri are without transverse striation. Darwin found the stomach perfectly empty in the animal examined by him. Having reached the *Nauplius,* the extreme outpost of the class, retiring furthest into the gray mist of primitive time, we naturally look round us to see whether ways may not be descried towards other bordering regions. By the structure of the abdomen in *Nauplius* we might be reminded, like Oscar Schmidt, of the moveable caudal fork of the *Rotatoria,* which we may regard as near allies of the *Crustacea,* or at any rate of the *Arthropoda.* But I can see nothing certain. Even towards the nearer provinces of the *Myriopoda* and *Arachnida* I can find no bridge. For the *Insecta* alone the development of the *Malacostraca* may perhaps present a point of union. Like many *Zoëæ,* the *Insecta* possess three pairs of limbs serving for the reception of nourishment, and three pairs serving for locomotion; like the *Zoëæ* they have an abdomen without appendages; as in all *Zoëæ* the mandibles in insects are destitute of palpi. Certainly but little in common compared with the much which distinguishes these two animal forms. Nevertheless the supposition that the *Insecta* had for their common ancestor a *Zoëa* which raised itself into a life on land, may be recommended for further examination. Much in what has been adduced above may be erroneous; many an interpretation may have failed, and many a fact may not have been placed in its proper light. But in one thing I hope I have succeeded—in convincing unprejudiced readers that Darwin's theory furnishes the key of intelligibility for the developmental history of the *Crustacea,* as for so many other facts inexplicable without it. The deficiencies of this attempt, therefore, must not be laid to the charge of the plan drawn out by the sure hand of the Master, but solely to the clumsiness of the workman who did not know how to find the proper place for every portion of his materials." (Williamson, *Quarterly Journal of Microscopical Science,* viii., p. 35; Salter, *Journal of the Linnean Society,* iv., p. 30; Brandt, *Bulletin de l'Acad. Sci. St. Petersburg,* viii., col. 416; Müller, *Facts for Darwin,* translated by W. S. Dallas; *Record of Zoological Literature,* vols. i.—iv.)

CTENOPHORA. The information respecting this group of organisms contained in E. C. will be found under the headings ACALEPHÆ, BEROË, CALYMMA, and CALLIANIRA. Its rank in the animal world has been variously estimated, but most of the best authorities now agree that it is an order in the class *Actinozoa,* and that it should be placed at the head of this class. Professor Clark objects to this view, and maintains that *Ctenophora* should be regarded as a class intermediate between the *Hydrozoa* and the *Echinodermata.* In some points the group has considerable structural resemblance to the *Hydrozoa* and *Actinozoa,* while in others, which appear to be of high classificatory value, since they occur in every species, it approaches the *Echinodermata,* and at the same time differs markedly from the other classes mentioned. Macdonald considers that the order forms an intermediate link between the *Actinozoa* and *Polyzoa.* These differential points would induce us, individually, to pause before endeavouring to make all parts of the organism conform to the *Actinozoa* type of structure, since mistakes may arise from regarding these objects from a preconceived point of view when we are insufficiently acquainted with their structure and life history. In order to bring out the general features of the *Ctenophora,* we propose to mainly confine our attention to one species. This is the *Pleurobrachia rhododactyla* of the American shores of the North Atlantic, which appears to represent in that area the common *Pleurobrachia pileus* of the European shores. The synonymy of those species is so confusing that we will not attempt to point out its intricacies, but will simply say that both have been named *Cydippe pileus;* and that the figure described under this name in E. C. vol. i. col. 34, apparently belongs to the European species.

The general appearance of the species under notice may be gathered from the following observations by Professor Agassiz:—"There can be scarcely anything more beautiful to behold than such a living transparent sphere sailing through the water, coursing one way or another, now slowly revolving upon itself, then resuming a straight course, or retrograding, advancing or moving sideways in all directions with equal precision and rapidity, then stopping to pause, and remaining for a time almost immovable, a slight waving of some of its vibrating organs easily counterbalancing the difference of its specific gravity and that of the water in which it lives. So *Pleurobrachia* may appear at times, and so does it also appear when moving in a state of contraction. But generally when active, it hangs out a pair of most remarkable appendages, the structure and length and contractility of which are equally surprising, and exceed in wonderful adaptation all I have ever known among animal structures. Two apparently simple, irregular and unequal threads hang out from opposite sides of the sphere. Presently these appendages may elongate, and equal in length the diameter of the sphere, or surpass it, and increase to two, three, five, ten, and twenty times the diameter of the body, and more and more, so much so that it would seem as if these threads had the power of endless extension and development. But as they lengthen they appear more complicated; from one of their sides other delicate threads shoot out like fingers, forming a row of beards like those of the most elegant ostrich feathers, and each of these threads itself elongates till it equals in length the diameter of the whole body, and bends in the most graceful curves. These two long streamers, stretching out in straight or undulating lines, sometimes parallel, then diverging or variously curving, follow the motions of the main sphere, being carried on with it in all its movements, which are no doubt influenced by them to a considerable extent. Upon considering this wonderful being, one is at a loss which most to admire, the elegance and complication of that structure, or the delicacy of the colours and hues, which, with the freshness of the morning dew upon the rose, shine from its whole surface. Like a planet round its sun, or, more exactly, like the comet with its magic tail, our little animal moves in its element as those larger bodies revolve in space, but unlike them and to our admiration, it moves freely in all directions; and nothing can be more attractive than to watch such a little living comet as it darts with its tail in undetermined ways, and revolves upon itself, unfolding and bending its appendages with equal ease and elegance, at times allowing them to float for their whole length, at times shortening them in quick contractions and causing them to disappear suddenly, then dropping them, as it were, from its surface, so that they seem to fall entirely away, till, lengthened to the utmost, they again follow in the direction of the body to which they are attached, and with which the connection that regulates their movements seems as mysterious as the changes are extraordinary and unexpected. For hours and hours I have sat before them and watched their movements, and have never been tired of admiring their graceful undulations. And though I have found contractile fibres in these thin threads, showing that these movements are of a muscular nature, it is still a unique fact in the organisation of animal bodies that parts may be elongated and contracted to such extraordinary and extensive limits by means of muscular action. And what is so surprising is not so much the sudden and powerful contraction which brings within the compact limits of a pin's head the whole mass of these tentacles that a moment before were floating so elegantly through such a great extent in the water, as the relaxation, which takes place in an absolutely passive manner; for, when watching them, we are suddenly struck with astonishment on finding that the tentacle which we expected to see drop to the bottom of the jar is still in organic connection with the body from which it hangs. At one moment the threads, when contracted, seem nodose; next, when more elongated, these knots are stretched into the appearance of a spiral; next, the spiral, elongating, assumes the appearance of a straight or waving line. But it is especially in the successive appearances of the lateral fringes arising from the main thread that the most extraordinary diversity is displayed. Not only are they stretched under all possible angles from the main stem, at times seeming perpendicular to it, or bent more or less in the same direction, and again as if combed into one mass; but a moment afterwards every thread seems to be curled or waving, the main thread being straight or undulating; then the shorter threads will be stretched straight for some distance, and then suddenly bent at various angles upon themselves, and perhaps repeat such zig-zags several times, or they may be stretched in one direction and bent at various angles in the plane of another direction; then they may be coiled up from the tip, and remain hanging like pearls suspended by a delicate thread to the main stem, or like broken rods which lie bent in an acute angle upon themselves with as stiff an appearance as if the whole was made up of wires; and, to complete the wonder, a part of the length of the main thread will assume one appearance, and another part another, and pass from one to the other in the quickest possible succession; so that I can truly say I have not known in the animal kingdom an organism exhibiting more sudden changes and presenting more diversified and beautiful images, the action meanwhile being produced in such a way as hardly to be understood. For, when expanded, these threads resemble rather a delicate fabric spun with the finest spider's thread, at times brought close together, combed in one direction without entangling, next stretched apart, and preserving in this evolution the most perfect parallelism among themselves, and at no time and under no circumstance confusing the fringes of the two threads: they may cross each other, they may be apparently entangled throughout their length, but let the animal suddenly contract and all these innumerable interwoven fringes unfold, contract, and disappear, reduced as it were to one little drop of most elastic india-rubber. Week after week I have preserved these animals alive, and have never been tired of comparing again and again their changes in these thousandfold developments of their appendages. I have called together those who felt the slightest curiosity for such objects to witness these phenomena, and have found them all interested to the utmost, and if I have anything to regret, it is not the time lost in this contemplation; for the more I became familiar with the sight, the more was I impressed with its beauty, as I could contrast with the new forms presenting themselves before my eyes those different states with which I had been familiar before; but the circumstance that the time was too short to trace such a connection between all the microscopic details of their structure and their functions, as would fully explain the latter; although I am aware that I have noticed many particulars which had not been observed before."

This lovely object, tinted with the most delicate hues, and so diaphanous that the minute structural details can hardly be discriminated, is not strictly spherical, nor do all its outlines follow the same curvature. At one part there are two slight linear protuberances which mark the position of the mouth; and at the opposite extremity there is a slight depression; the line joining these two parts represents the medial, vertical, or actinal axis of the animal. The end where the mouth is placed may be termed the oral extremity, and the opposite the aboral extremity. Agassiz uses the terms actinal and abactinal to denote these parts. The direction of the oral fissure is believed to be always homologically the same, and the plane which coincides with it is uniformly termed the *cœliac*, or fore and aft diameter, since it indicates the antero-posterior line of the body. In many *Actinozoa* the two ends of the oral fissure are somewhat different, so that we can distinguish which is front and which is back; but in *Pleurobrachia* they are undistinguishable. The plane here referred to divides the body into two lateral halves, which are precisely identical. The plane at right angles to the cœliac may be termed the *diacœliac diameter;* it may be readily distinguished from its position relatively to the mouth, and from its coinciding with the line of the tentacles, from which circumstance it has sometimes been called the *tentacular* diameter. It is necessary to bear in mind the relations of these parts one to the other, as without a fixed position, it is almost impossible to accurately compare these organisms one with the other; for in some the oral extremity is habitually directed upwards, as in *Pleurobrachia;* in others downwards, as in *Bolina;* while in yet others it is more or less horizontally directed, and situated at the forward end when in motion, as in *Idyia*. The descriptions of the position of the organs have mainly had reference to the usual position of the animals, so that they have been as often in harmony with as in contradiction to the real homological relation of the parts.

In *Pleurobrachia* the body is slightly elongated in the direction of the actinal axis, and the cœliac diameter is somewhat longer than the diacœliac; in other words, it is compressed laterally. The surface of the body bears eight rows of locomotive flappers or ctenophores, so called from their comb-like arrangement. These rows run in the actinal direction; but they do not extend to either pole of the sphere. At one pole is the mouth with a surrounding area; and at the opposite pole is another elliptical area free from ctenophores, in the centre of which is a minute spherule, the nature of which is uncertain. The rows are not equidistant, but are arranged in pairs, two pairs being grouped together on each side of the mouth, and presenting a good illustration of that remarkable combination of bilaterality and radiation which is so frequently met with in this order. Such is the usual form assumed by this species, but it must not be supposed that it is stereotyped and unalterable. On the contrary, every part is capable of extension and dilation; the mouth sometimes becomes oval or circular; the body is sometimes elongated and almost cylindrical. This variation of form is similar to what may be seen in sea anemones, each species of which has a characteristic shape, and yet, as any sea-side observer may notice, anemones will occasionally distort themselves in the most extraordinary fashion.

We will next briefly describe the nutrient system, commencing with the mouth. This aperture leads into a cylindrical canal, which extends for rather more than half the length of the actinal axis, and contracts slightly at its lower extremity. This may be homologous with the digestive cavity of an actinozoon, or, as seems to us quite as probable, the polypite of some of the quadripartite *Medusidæ*. It opens into a shorter but much wider cavity, which is called the 'funnel' from its shape, due to the gradual diminution of its diameter towards the aboral extremity, but before reaching that extremity it bifurcates, and forms two *apical canals*, which pass on either side of the spherule above-mentioned, or ctenocyst, and terminate in two pores, known as the *apical*, or *anal*, or *cœliac* pores. From the oral and wide extremity of the funnel issue a pair of canals, which trend upwards parallel to the flat sides of the digestive sac, but they terminate in blind ends. They are designated the *paragastric* canals. Lastly, there is a third pair of canals which diverge from the upper corners of the funnel and proceed, in a more or less horizontal direction, towards the pits in which the tentacles are lodged, but before reaching them each canal bifurcates, and each branch again divides into two, so that ultimately there are eight radial canals. These canals open into eight others which follow the direction of the actinal axis, and underlie the rows of locomotive flappers, whence they are termed the *ctenophoral* canals. They terminate cæcally at both extremities. This elaborate system of vessels answers to the somatic cavity of an Actinozoon or Hydrozoon, and performs the same functions. The digestive sac is adapted to the extraction of the alimentary portion of the food, while the nutrient vessels are for the distribution of the nourishing fluid to all parts of the body. This fluid is so largely composed of water that it may be regarded as a weak solution of animal matter. It is not blood, not being of so specialised a nature. Professor Agassiz seems to consider it analogous to chyme, since he terms the nutrient vessels the chymiferous system. The waste products are discharged through the cœliac pores, which Agassiz objects to being called anal pores, since they are immediately connected with the nutrient vessels, and not with the digestive system. They perform the functions of an anus, but as they occur in a different part of the organism they should not be considered to be homologous with that part. The shape and size of the various passages are constantly altering according to their degree of distension or contraction. Having sketched the general position of the canals, we may briefly notice their functions. The food, which chiefly consists of other *Ctenophoræ*, is taken in through the widely distended mouth, and retained in the digestive sac until reduced to a pulpy disintegrated condition. It is then discharged along with a large quantity of water into the funnel, and there kept in constant rotation by means of cilia. It is next forced into the canals of one side by the muscular contraction of the opposite side of the body. In these canals the fluid is made to follow an up-and-down current by means of cilia which line all the passages. After an interval the muscular fibres of the turgescent half of the body are violently contracted, and the fluid is forced into the canals of the opposite half, there to circulate for a short space of time. There appear to be no minute capillary tubes, so that probably the direct contact of the fluid with the tissues is effected by osmotic action. The tentacular apparatus is very complicated, and it is not quite clear from the published accounts in what way the process of extension and contraction is effected. The base of the tentacle is a large mass situated towards the oral extremity of the body, and connected with one of the longitudinal canals. From this point it extends through the substance of the body and emerges on the aboral side. The tentacular pit is open to the surrounding water, but has no communication with the interior of the animal. The tentacle itself is hollow and is connected with the system of nutrient vessels. The shortening and lengthening of the tentacles appear to have a close connection with the movements of the body from one side to the other, but, independent of this, muscular action also appears to play a conspicuous part. Professor Agassiz says, "the two tentacles with their elongated cavity, and the vertical tubes extending along the base of the tentacular apparatus constitute, indeed, most complicated pieces of machinery, in which hydrostatic power, elastic levers, and the contraction of the motory cells, give rise to highly complicated combinations and most diversified phenomena." He, however, denies the existence of muscular fibres, although, on a previous page, he states he has seen them. He seems to conceive that the motor power resides in certain cells, which form the great bulk of the body, and have a special arrangement, as will be noticed presently. At present we would observe that what Agassiz believes are the margins of the cells are, according to Professor Clark, elastic fibres. Thus Clark remarks:—"At the time the investigation of the gelatiniferous mass of *Pleurobrachia rhododactyla*, Ag., was made, I had not in my possession lenses of the proper definition and working distance to make out the histological elements with the requisite care that such excessively transparent bodies demand, and, therefore, using inferior lenses, I fell into an error which I am only too glad to correct. Since that time I have obtained one of Tolles' half-inch objectives with an exceedingly sharp definition and an extraordinary working distance; so that I have been enabled to work with perfect freedom upon the living animal and without injuring its tissues in the least. What formerly I mistook to be the outlines of the walls of enormous cells are in reality elastic fibres. The mistaking the fibres for the profile of cell walls does not affect the arrangement in the least, as I formerly described it, and which I have since verified with my new objectives. The elastic fibres assume various forms according to the degree of expansion or contraction of the animal; sometimes they are perfectly straight, and at others they are contracted either in a loose spiral, or retracted into a loose coil. This is most easily observed in young specimens. In the young of another Ctenophoran, viz., *Bolina alata*, Ag., about $\frac{1}{32}$nd of an inch in diameter, at which size its proportions, shape, the considerable depth of the tentacular sockets, and the length of its tentacles render it remarkably like a *Pleurobrachia*, the elastic fibres are very few, but quite conspicuous, and have a peculiar mode of branching. Single fibres extend radiatingly from the corners of the stomach; when about half way to the surface of the body, each fibre forks two or three times, and then one prong goes to each of the two nearest longitudinal chymiferous tubes, and the third one extends to the base of the deep tentacular socket. This is the general arrangement at this age, although occasionally one of the prongs of the fork is absent or only partially developed. Sometimes each prong forks again at a narrow or wide angle. From the tentacular sockets fibres extend also to the surface midway between the mouth of the former and the adjacent longitudinal chymiferous tube. So few are all the fibres, however, that with a casual glance they might be mistaken for light, unimportant bodies, here and there, instead of such methodically arranged bodies." The body is divided into eight regions by the ctenophoral bands, which Agassiz designates *interambulacral;* while the bands themselves constitute the *ambulacral* regions. The former are the widest and protrude slightly beyond the latter, so that there are eight broad ridges, and eight narrower depressions. The broad ridges are formed by a system of cells which trend across the interambulacral spaces; so that when they contract the ctenophores are brought closer together. A set of cells with a parallel trend surround the mouth. Each of the rows of locomotive flappers is underlain by cells transversely disposed; and the flappers themselves, Agassiz suggests, are thus external prolongations of the cells, and with his views respecting the nature of the cells, he would thus explain the activity which seems to be inherent in the flappers. Thus he states, "as these cells are simple prolongations from the midst of other similar cells, we should take it for granted that they have similar motive powers; for no action of special muscles—supposing they were present, which is not true—could be so transmitted from the base along the flapper as to give it that peculiar curve which it frequently assumes when in a stationary condition; but any one may understand how the cells themselves can assume such a curve, and that each combined row of cells moves by the inherent power of its components, for, as we have frequently observed, when the flappers are minutely split up from edge to base, each cell vibrates isolatedly, and either in consonance with the others or at random." The cells already noticed occupy the superficial parts; all the deeper seated and more solid portions of the body are also composed of motory cells, whose long axes stretch in curves from the cœliac axis towards the surface, and hence their lines of action are at right angles to those of the superficial cells. The tentacles are lined externally by a layer of vesicles which are true urticating organs, analogous to those found in other Actinozoons and in the Hydrozoons; but the structure of these organs is peculiar. Those of the *Hydrozoa* and *Actinozoa* generally are described under ACTINOZOA and HYDROZOA, E. C. S. In *Pleurobrachia*, and probably most *Ctenophora*, they are spherical when not in contact, covered externally with minute granules, and have coiled within them a simple solid thread which is attached by one end to the inner wall, while the opposite end is free. When used for prehensile or offensive purposes the thread is evolved by simple uncoiling, and is protruded from the cell, not by eversion or bursting through, but by being discharged through an aperture formed by the retraction of the walls of the cell. Adhesion is effected by simple contact; and the tenacity of hold is said to be very great. This is very different from the mode of action in the *Hydrozoa* and most of the *Actinozoa*, in which the threads are evolved by the eversion of the lasso cell, and a holdfast is obtained, not by simply sticking to the foreign body, but by the ends being sent into its substance and retained there by outstanding spikes. The ctenocyst is another feature peculiar to the *Ctenophora*. It is a black speck in the depression on the aboral side of the body, but its functions are problematical. It has been variously surmised to be an eye speck, or an auditory capsule. It has a dense, elastic wall, and contains a fluid in which lie a number of minute concretions which appear to be subject to a peculiar vibratory movement. So far as structure is concerned this rather resembles an otolith, such as occur in *Crustacea*, than an organ of vision, however rudimentary. It is believed to correspond with the marginal spherules in the *Medusidæ*, and perhaps the terminal specks in star fishes. The existence of a nervous system has not been established; but the following passage from Greene will indicate what little is known on this point:—"The nervous system of the *Ctenophora* consists either of a single ganglion or of a pair of ganglia closely approximated, giving origin to numbers of delicate nerve-like cords. The ganglion lies deeply seated within the pyramidal mass of ectoderm included between the apical canals, towards the narrow extremity of which its apex is directed, while its base rests upon the surface of the ctenocyst. In form it is sub-pyriform, or bluntly conical; anatomically it seems resolvable into a thin transparent wall enclosing granular contents; in colour, it is most frequently pale yellow. From this central mass issue two principal series of nervous cords, one of which arches inwards towards the walls of the digestive canal, and in some cases separates into four sets or bundles to supply the principal regions of the body. The nerves of the second series, usually eight in number, are distributed along the rows of surrounding combs so as to be between the latter and their corresponding canals; these cords appear dilated at intervals into numerous minute ganglionic filaments, one for each of the ciliated plates; an arrangement which, if corroborated by subsequent investigations, would go far to throw some light upon the singular and quasi-independent movements which these combs perform in the living animal. There is still, however, much diversity of opinion as to the true interpretation of the parts just described. Kölliker, while recognising in *Chiajea* the presence of delicate cords extending from comb to comb, expresses himself nevertheless as very doubtful of the existence of a nervous system in any of the *Ctenophora* which he had himself investigated. Agassiz is equally sceptical. On the other hand the careful observations of Will, Milne-Edwards, and, more recently, of Gegenbaur, point to an opposite conclusion. Somewhat similar are the views of Frey and Leuckart. All the preceding writers are unanimous in rejecting the prior account of the nervous system of *Pleurobrachia* given by Grant, who describes a double nervous ring surrounding the mouth, in the course of which he thought he could detect eight ganglia, each giving off on either side two fibres, and a fifth large filament, traceable onwards beyond the middle of the body. Yet this description, when carefully considered, is less irreconcileable with the views expressed on the same subject by other observers than seems to be usually supposed."

The development of *Pleurobrachia rhododactyla* has been described by A. Agassiz. The earliest phase of the embryo is passed within the egg, in the fluid of which it swims about actively. At a very early period of its existence it has somewhat the appearance of the adult, being slightly pear-shaped, one end being round, and the other flat. At first it is, apparently, a solid mass, but a cavity is soon formed at the round end, which end will ultimately be the oral pole; and the cavity is the rudimentary digestive sac. At the opposite pole of this body is a large transparent protuberant sphere, with two or three granules, which is easily recognised as the ctenocyst. At the two sides are two small protuberances, the indications of the future tentacles; and on either side of the tentacular knobs is a very short double row of locomotive flappers. At a subsequent stage the digestive cavity has grown from a circular into an elliptical space, and the tentacular knobs have elongated into long tentacular processes, which are gracefully curved, like the handle of a jar. The diacœliac diameter increases faster than the cœliac. The digestive cavity continues to widen and elongate, and the ctenophores extend farther along the body. By the time the cavity is on a level with the oral end of the rows, a small spherical cavity occurs beneath the ctenophores, which gradually increase into a long canal, and the space separating it from the digestive cavity as gradually diminishes. The flappers become longer, and soon equal in length the semi-diameter of the body. The tentacles also increase up to a length of three or four times that of the body. By this time a small space has opened out beneath the ctenocyst, and has given rise to two branches opening on the surface of the body. This is the funnel, with its cœliac canals and pores. While all this has been going on, the creature has been incessantly swimming round and round its prison. Changes still progress; the digestive and ambulacral cavities unite, the wall covering the oral extremity of the digestive cavity is perforated, and as soon as the mouth is formed the embryo escapes from the egg. The changes then follow each other in more rapid succession. The digestive cavity assumes the compressed condition normal to the mature form when not distended with food; the rows of locomotive flappers are transformed from double rows into two single rows; and the system of nerves which radiate from the funnel to the longitudinal or ambulacral canals, is elaborated. The tentacle, which was a simple thread, is now provided with a series of slender offshoots; the rows of flappers have extended far beyond the aboral extremity of the digestive cavity; and the ctenocyst now lies in a hollow. At this stage the embryo is about half-an-inch in diameter, and has all the appearance of the adult form, the difference between the cœliac and diacœliac diameters being much less than in the earlier phases. The adults are bisexual, the ovaries and spermaries being contained in the same individuals. They are arranged on the partitions between the longitudinal or ambulacral vessels, each partition containing on either side the same sexual organ; hence the arrangement is that each alternate partition has spermaries, and the intermediate ones ovaries. This is the usual arrangement in the order, and it is an arrangement which recalls to mind that which is found in the *Actinozoa*. But there is this difference, that whereas in *Ctenophora* bisexuality is the rule, in *Actinozoa* it is the exception.

One very noticeable feature is that although *Ctenophora* have the general structural plan, partly of the *Actinozoa* and partly of the *Hydrozoa*, it differs from both in its mode of development, and in its embryo stage presents no greater resemblance to either than when adult. The characteristic ctenophores make their appearance very early, and there is nothing analogous to the sessile condition which prevails throughout the *Actinozoa* (exclusive of the *Ctenophora*) and the *Hydrozoa*. Further, we may notice that the developmental changes are as slight as in the *Actinozoa*, and not to be compared with the varied series of forms through which the *Hydrozoa* pass. From an embryological point of view there seems to be great difficulty in recognising that the *Ctenophora* form an order in the class *Actinozoa*. But when we cast about to see whether the larvæ of *Ctenophora* resemble any other class in structure, there does seem to be a strong relation between the embryos of *Ctenophora* and *Echinodermata*. This is indicated by A. Agassiz, who observes that "in the bilateral symmetry of the *Ctenophoræ* we are constantly reminded of the general appearance of the Echinoderm larvæ, in which the radiate structure should still be so far apparent as not to be concealed by the bilateral symmetry. Looking at the *Ctenophoræ* as prophetic animals, we are able to understand the separation of the digestive cavity into two distinct parts. It is only what we find more fully developed in the Echinoderm larvæ; the separation of a sort of alimentary canal in *Ctenophoræ* from the rest of the digestive apparatus, exactly corresponding to what exists in Echinoderm larvæ. The connection between the water system and the digestive system is likewise precisely similar to that of Echinoderm in their larval state; for although in the adult star fish, or sea urchin, or ophiuran, there is no apparent connection between the ambulacral and digestive systems, yet in the young larvæ we can see that this connection exists, the water system being formed by diverticula from the digestive cavity; while the injections of Professor Agassiz have proved the existence, in the adult, of a similar connection in *Echinarachnius*, *Mellita*, and in *Clypeaster*. It was only after the embryos of Echinoderms had been compared with *Ctenophoræ*, that undoubted evidence of their identity of plan was obtained." The Ctenophora, in short, seem to have features common to them, and allied orders and classes; but, so far as we are competent to express an opinion, it seems that their relation is best expressed by calling them actinoid, or rather alcyonoid, medusæ, on which view the digestive sac of *Ctenophora* would correspond with the polypite of the *Medusidæ*. The funnel of *Ctenophora* would answer to the somatic cavity of the *Medusidæ*, or the part contained within the bell; but whereas in the one the digestive sac is dependent in the somatic cavity; in the other, it forms an adjunct to the cavity, the mouth being turned in the opposite direction. It would be difficult, however, to make our view clear without the aid of figures. Mr. Macdonald takes quite a different view of the matter.

He considers that the funnel and apical canals represent the intestine and anal canals, while the lateral passages alone form the somatic cavity; the rows of locomotive flappers are, in his view, the homologue of the brachial sac of the *Tunicata*, or the fringed arms of the *Brachiopoda*; that *Pleurobrachia* is the intermediate link between the *Actinozoa* and *Polyzoa*; and that the *Ctenophora* should be arranged along with the *Molluscoida* rather than with the *Cœlenterata*, as represented in the annexed table:—

Molluscoida.		
Intestine insulated from the somatic cavity.	With primary hæmal and final neural flexure.	*Ascidiozoa.*
	With simple neural flexure.	*Brachiopoda,* and *Polyzoa.*
Intestine straight, and communicating with the somatic cavity		*Ctenophora.*
Cœlenterata.		
Intestine obliterated; stomach communicating with the somatic cavity . . .		*Actinozoa.*
True stomach obliterated, its office being answered by the somatic cavity . .		*Hydrozoa.*

Taking the *Ctenophora* as a central group, he conceives that the others are modified forms, the modification being either progressive or retrogressive, and referable to either the alimentary or tentacular systems, as more fully shown below.

I.

Modifications of Alimentary System.

* Progressive.

Complete insulation of the intestine from the somatic cavity.

a. Primary type, with simple neural flexure. *Brachiopoda* and *Polyzoa.*

b. Secondary type, with primary hæmal and final neural flexure. *Ascidiozoa.*

** Retrogressive.

a. Primary type. Stomach more completely insulated by the addition of an intestine. *Actinozoa.*

b. Secondary type. Eversion and abolition of the true stomach. *Hydrozoa.*

II.

Additions affecting the Tentacular System.

* Progressive.

a. Primary type. Oral tentacula of *Brachiopoda* and *Polyzoa.*

b. Secondary type. Branchial tentacula. *Ascidiozoa.*

** Retrogressive.

a. Primary type. Oral tentacula of *Actinozoa.*

b. Secondary type. Oral tentacles of *Hydrozoa.*

The most convenient arrangement of this Order is that proposed by Gegenbaur as modified by Greene, of which we subjoin an outline:—

Sub-Order 1. *Stenostomata.*

Family 1. *Calymmidæ.*

Body furnished with a pair of antero-posterior oral lobes, and other smaller lateral appendages. Tentacles various, turned towards the mouth.

Family 2. *Cestidæ.*

Body ribbon-shaped, extended in a lateral direction, without oral lobes. Tentacles two in number, antero-posterior, turned towards the mouth.

Family 3. *Callianiridæ.*

Body produced into a pair of wing-like, lateral lobes, bearing the ctenophores. Tentacles two in number, lateral, turned from the mouth.

Family 4. *Pleurobrachiadæ.*

Body oval or spheroidal, without oral lobes. Tentacles two in number, lateral, turned from the mouth.

Sub-Order 2. *Eurystomata.*

Family 5. *Beroidæ.*

Body oval, elongated, without oral lobes. Tentacles absent.

(Agassiz, A., *Illustrated Catalogue of the Museum of Comparative Anatomy at Harvard College. No. 2. North American Acalephæ,* 1865; Greene, *Manual of the Cœlenterata,* 1863; Agassiz, L., *Contributions to the Natural History of the United States,* vol. iii.; Macdonald, *Trans. Roy. Soc. Ed.*, xxiii., p. 515; Clark, *Am. Journ. of Sci.*, Second Series, xxxv. p. 348.)

CUMBRIAN ROCKS [E. C. vol. ii. cols. 255, 256]. The views propounded under this head in the Cyclopædia are now known to be entirely erroneous. The oldest rocks in Cumberland, viz., the Skiddaw slates, are nearly on the same horizon as the Llandeilo flags of Wales, and are therefore newer than the rocks acknowledged to be Cambrian. The Skiddaw slates and Coniston limestone will be more particularly noticed under SILURIAN SYSTEM, E. C. S., where also reasons will be given why the Llandeilo flags are considered to be the lower boundary of the Silurian System. The arbitrary line employed by De la Beche is now useless, since there is no reason why fossils should not be found in any sedimentary rock in these islands, even if they date from Laurentian times. As the so called Cumbrian rocks are really the Cumberland development of the Llandeilo beds, no set of strata is entitled to this name.

CUSCUTA [CUSCUTACEÆ, E. C. vol. ii. cols. 261—263]. This genus has been carefully studied by Dr. Engelmann, who has published the results arrived at in the memoir referred to below. He has arranged the 77 species known to him in three large groups, distinguished by their styles and stigmata. The first, or *Cuscuta* group, comprises all the species having two equal styles and elongated stigmata. They are exclusively natives of the Old World, although one or two species have been introduced into America, but have only flourished there for a short time. The second, or *Grammica* group, comprises the species having two unequal styles, and abbreviated, usually capitate stigmata. They occur principally in South America, Oceanica, and the southern and eastern parts of Asia; but a few species penetrate into North America, and still fewer into Western Asia, Southern Europe, and Southern Africa. The third, or *Monogyna* group, embraces such species as have the styles entirely or partly united, and the stigmata capitate, ovate, or conic. The species of this group are also marked by their large size and thick stems. They principally occur in Asia, but a few stragglers have been found in Southern and Eastern Europe, South Africa, and the southern parts of North America.

These groups are divided into 9 sections, the characters of which are indicated below.

A. CUSCUTA GROUP.

1. *Eucuscuta.*—Styles nearly as long or longer, and as thick or thicker, than the filiform stigmata; capsule regularly circumscissile. This embraces 10 species. All the British varieties belong to this section. Two of them belong to *C. epithymum*, and to modifications of the same variety, viz., *α. vulgaris.* This is the common form in Central Europe; it extends from Great Britain on the west to the Caucasus on the east, and from Scandinavia on the north to Northern Italy and Northern Spain on the south. It is usually parasitic on the heath, but sometimes on clover, when it acquires a more luxuriant habit. This has caused it to be raised to the rank of a species under the name of *C. trifolii.* There are 9 other varieties of the same species. *C. Europœa* and *C. epilinum*, the other British species, also belong to this section.

2. *Epistigma.*—Subulate stigmata nearly sessile; capsule opening transversely without a regular jointed separation. There are 4 species, and all are Asiatic.

3. *Clistococca.*—Subulate styles longer than the short subulate stigmata; capsule baccate. Only one species (*C. capitata*) belongs to this section, and is restricted to the Himalaya Mountains, at elevations of from 6000 to 12,000 feet.

4. *Pachystigma.*—Cylindric or oblong stigmata thicker than the filiform styles; capsule bursting transversely. Three species belong to this section, all of which are inhabitants of South Africa.

B. GRAMMICA GROUP.

5. *Eugrammica.*—Stigmata capitate; capsule more or less irregularly circumscissile. There are 20 species in this section, and most of them inhabit South America, the West Indies, and Mexico; one extends into the south-western parts of the United States, two are peculiar to that region, and two are natives of Asia.

6. *Clistogrammica.*—Stigmata capitate; capsule baccate. This section is the richest in species, numbering 28. They are generally distributed throughout North and South America, and the islands of the Pacific Ocean. One species (*C. obtusiflora*) is remarkable for the great extent of its range and the number of its varieties. It is found in North and South America, the islands of the Pacific Ocean, Asia, and Europe. Its variation in cha-

racter will be at once seen by the following synopsis of its form, given by Dr. Engelmann :—

a. Scales ovate or spatulate.
  * Scales small, shorter than the tube of the corolla; var. *vera*, South America.
  ** Scales large, equalling or exceeding the tube of the corolla; all parts of the flower dotted with glands; var. *glandulosa*, from the West Indies and the southern parts of the United States.
  *** Lobes of calyx and corolla, broadly oval, or almost orbicular; scales large; var. *latiloba*, from India.
b. Scales bifid, and often very small.
  * Flowers five-parted, usually glandulous; scales very small, sometimes almost obliterated; var. *Australis*, from New Holland and China.
  ** Flowers often four-parted, scarcely glandulous; scales as in the last; var. *breviflora*, from Southern Europe.
  *** Flowers and scales larger; lobes of calyx and corolla narrow; var. *cesatiana*, from Italy and Central Asia.
  **** Calyx large, capulate, lobes somewhat carinate; var. *Cordofana*, from Africa.

C. racemosa is another variable species, which is spread over the greater part of South America, and is a sort of geographical counterpart to *C. Gronovii*, which is a similarly common and wide spread species in North America.

7. *Lobostigma.*—Top of clavate styles lobed at the upper stigmatose surface. The only species belonging to this section is a native of Tasmania.

C. MONOGYNA GROUP.

8. *Monogynella.*—Stigmata capitate or ovate, united or distinct. Of the 8 species belonging to this section, 5 are Asiatic, 1 is peculiar to the island of Timor, 1 to South Africa, and 1 to Texas.

9. *Callianche.*—Stigmata conic or almost subulate; corolla large and deciduous. The only species known inhabits East India and the adjoining islands.

Some botanists have split the dodder tribe (*Cuscutaceæ*) into four genera; but Dr. Engelmann does not admit that the species can be included in more than one genus. It has been supposed that the different species of dodder had a predilection for certain plants or families of plants; and that the nursing plant had an influence on the form and development of the parasite. Dr. Engelmann thinks that this influence is very limited, and that it depends rather upon the soil than upon the plant. If some species seem to be constant parasites of the same plant, as in the case of *C. Europæa* upon the common nettle, of *C. epithymum* upon the common heath, of *C. lupuliformis* upon the willow, and of *C. epilinum* upon flax, it is probably because the circumstances which best suit the nursing plant are also most suitable to the parasite. This is supported by the fact that when once attached to a plant the parasite dodder throws out branches, and coils round any plant in the neighbourhood: they grow on anything that will afford them nourishment, even on their own branches and flowers. Thus *C. epilinum* attaches itself not only to the flax, but also to the surrounding weeds, and may be cultivated on *Vicia*, *Impatiens*, and many other plants. Rich nourishment on succulent plants causes a luxuriant growth in the parasites, so that both organs and flowers are enlarged. Thus *C. epithymum* in clover fields becomes what has been called *C. trifolii; C. Europæa* on vetches becomes *C. viciæ;* and many other instances might be given.

(Geo. Engelmann, *Systematic Arrangement of the Genus Cuscuta, &c. Trans. Acad. Sci. St. Louis*, vol. i. pp. 453—523.)

CYPSELIDÆ. A family of birds, whose powerful flight, weak legs, and wide gape adapted for the capture of insects, have afforded well-marked characters whereby to define them. Relying upon these external characters only, this family has long been associated with the common house swallow and its allies under the appellation of the *Hirundinidæ*. So long has this association been supported by eminent authorities, that ornithologists have been slow to admit that the swallows and the swifts ought to be widely separated in our classifications. The old time-honoured opinion is adopted in the E. C., where the swallows and the swifts are mingled together under the headings SWALLOW TRIBE, cols. 969—977, and HIRUNDINIDÆ. The distinctness between the groups which composed the old family *Hirundinidæ* is to a certain extent recognised in the first article referred to, since both Bonaparte and G. R. Gray are there represented as placing the swifts in one sub-family, the *Cypselinæ;* and the swallows in a second, the *Hirundininæ*. If general habits and external conformation are deemed to be the most important indication of the affinity of a bird, the swallows and the swifts will still be collocated in the same family; but if the physiological and anatomical plans of structure ought to overrule similarity of outward form and habits in the determination of affinities, then we must admit with L'Herminier, Nitzsch, Burmeister, and Sclater, that the swifts should be separated from the swallows, and be placed next to the humming birds (*Trochilidæ*), and the goat-suckers (*Caprimulgidæ*) in the natural system of classification. L'Herminier did this upwards of forty years ago; Nitzsch pointed out the wide difference in the nature of the feathers of the swifts and the swallows, and condemned their association; and Sclater has added the weight of his authority on the same side in his 'Notes on the genera and species of *Cypselinæ*' (Proc. Zool. Soc. 1865, p. 593). Prince Lucien Bonaparte has also conformed to the newer views. In his "Conspectus systematis ornithologæ" (An. des Sciences Naturelles, 4th series, tome 1), he divides the order *Passeres* into two tribes, the *Oscines* and the *Volucres*. The *Hirundinidæ* form the last family in the tribe *Oscines;* while the *Trochilidæ*, *Cypselidæ*, *Steatornidæ*, and *Caprimulgidæ* are the last four families in his tribe *Volucres*.

Professor Owen, in 'The Anatomy of Vertebrates,' vol. ii., says the birds corresponding to the order *Insessores* of Vigors are grouped in the three orders *Cantores* (which answers to the *Oscines* of Bonaparte), the *Volitores*, and the *Scansores* which two together answer to the *Volucres* of Bonaparte). The swallows are placed at the end of the *Cantores*, and the swifts at the beginning of the *Volitores*; so that, although placed in separate orders, the swallows and the swifts come next to each other.

There are many peculiarities in the osteology of the swifts, and one or two of these may be mentioned. Possessing, as they do, almost unrivalled powers of flight, the swifts have a sternum almost as strong, bony, and arched, and the keel nearly as highly developed, as the same parts in the humming-birds. The body of the sternum, when seen from in front, is seen to widen gradually from before to behind; the lateral margins curve gradually outwards, and the costal border is generally coincident with the lateral margins themselves; the posterior margin is generally convex and entire; and altogether the general form may be aptly compared to that of the common bronze socketed celt of Ireland. The keel of the sternum springs from the hindmost margin, and rises with a gentle curve which overarches beyond the anterior margin of the body of the sternum. The projecting part is round, and the anterior edge of the keel is concave. The height of the keel is equal to the breadth of the sternum. The manubrium is simple, and in most cases quite rudimentary. The body of the sternum presents different degrees of ossification in the different genera. In *Cypselus*, more especially the stronger species, it is almost completely ossified; in *Chætura* there are two holes or foramina; in *Collocalia* there are four small foramina; and in *Dendrochelidon* there are four large foramina. The coracoids are short and strong. The furcula form a broad curve, are completely anchylosed at the apex, which reaches far short of the anterior margin of the keel, and at about the level of its mid-height. The exceptions above indicated had reference to the sternum of *Dendrochelidon*, the body of which has a rounded anterior margin, as seen from in front; a concave posterior margin; costal borders partially distinct from the lateral margin; and the apex of the furcula almost touching the anterior margin of the keel. The form of the body of the sternum, seen from in front, is like the outline of a bell, and not of a bronze celt. In these and other points it somewhat approaches the cantorial type of sternum, but Dr. Bernstein and Dr. Sclater maintain that its general character is essentially cypseloid.

Two of the genera of the *Cypselidæ*, viz., *Cypselus* and *Panyptila*, are remarkable for the construction of the feet. In all other known birds (with perhaps the exception of some goatsuckers) the phalanges follow a progressive number, according to the position of the digit; but in the genera named the inner, medial, and outer digits have three phalanges each. This peculiarity, together with the unusual position of the posterior digit, has been employed by Dr. Sclater as an important classificatory character. His arrangement is as follows :—

A. *Cypselinæ.*—Tarsi feathered; external and medial digits with three phalanges; hallux directed forwardly or laterally.

1. *Cypselus.*—Tarsi feathered, but digits naked; hallux directed forwardly.
2. *Panyptila.*—Tarsi and digits feathered; hallux directed laterally.

B. *Chæturinæ.*—Tarsi naked; the digits with the normal number of phalanges; hallux implanted behind, and sometimes capable of being turned forwards.
  a. Tarsi longer than the middle digit.
    * Rectrices spiny.
      1. *Chætura.*—Rachidian apex projecting.
      2. *Cypseloides.*—Rachidian apex not projecting.
    ** Rectrices not spiny.
      3. *Collocalia.*
  b. Tarsus shorter than the middle digit.
      4. *Dendrochelidon.*

Adopting the information given in Dr. Sclater's paper, as also the geographical regions proposed by him, it appears that there are 49 well-recognised species, and that members of this family occur in every region of the globe. The Indian and the South American regions have each afforded 18 species; the African and the Australian have each afforded 8 species; the Palæarctic contains 6; and the North American only 3. From these figures it will be gathered that 10 of the species, or about 20 per cent. of the whole number, occur in more than one region. As these regions do not answer the purpose of illustrating the distribution of the *Cypselidæ*, some further remarks seem to be required. This family occurs in two distinct geographical groups: the one, comprising 29 species, is confined to the Old World; and the other, comprising 20 species, to the New World; and no species is common to both. The two principal genera, *Chætura* and *Cypselus*, are common to the two areas; *Collocalia* and *Dendrochelidon* are restricted to the Old World; and *Panyptila* and *Cypseloides* are confined to the New World. This will be better seen in the following table:—

Palæogæic Species.	Neogæic Species.
Cypselinæ.	Cypselinæ.
Cypselus. 12 sp.	Cypselus. 4 sp.
	Panyptila. 3 sp.
Chæturinæ.	Chæturinæ.
Chætura. 6 sp.	Chætura. 9 sp.
	Cypseloides. 4 sp.
Collocalia. 6 sp.	
Dendrochelidon. 5 sp.	

In the species of *Cypselus* of the Old World the principal centre appears to be the north-east portion of Africa—that is, Abyssinia and Upper Egypt. From thence they spread out in all directions, the boundaries being Cape Colony, Madeira, Ireland, Norway, Sweden, Northern Asia, China, the islands off the northern shores of Asia, and Ceylon. One species extends to Australia, but as yet it has not been met with in the area between the Malay peninsula and Cape York, and therefore we prefer not to include Australia amongst the limiting boundaries of the cypseline area at present. Towards the outer limits of this area the species are comparatively few, and are resident during the summer months only. But as we approach Abyssinia and India the species appear to become more numerous. In some localities a greater or less number of the individuals of the species appear to be permanent residenters. *C. unicolor* is only known in Madeira, and it is to be seen there all the year round. The two British species occur in Palestine, but they arrive thence each spring from regions farther south. The same country also has a third species (*C. affinis*), which ranges from India and Cape Colony to Palestine. The Palestine individuals remain permanently in the country, and are said by Mr. Tristram to be restricted to the valley of the Jordan. This species is remarkable for its habits being different in Palestine from what they are in India. In the latter country, Jerdon says it builds in colonies, wherever there are large towns or old buildings. The nests are composed of feathers, straws, &c., agglutinated together by the birds' saliva. Occasionally they are seen breeding in rocks. Tristram says of the Palestine bird: "Its note is peculiar—a gentle and melodious note-wail of three semi-tones, sharply repeated when alarmed. It breeds in colonies, and has laid its eggs when *Cypselus melba* arrives, and hatched its young before the return of *C. apus.* The nest is most peculiar, under an overhanging cliff, generally at a height of from 300 to 400 feet above any accessible stand-point. The nests are clustered side by side and one upon another; formed not like those of other swifts, but of straws and quill-feathers strongly agglutinated by the birds' saliva, and without any lining." In this locality it appears to build nowhere else but about the rocks.

The Old World species of *Chætura* live in the same area as the *Cypseli*, but their range is not quite so wide, since no species appears to have yet been met with in any part of Europe.

Collocalia dwells along the southern margin of the Cypseline area. It is for the most part restricted to islands; its species being scattered over the mazes of archipelagoes stretching from the Fiji islands in the east to Ceylon and Mauritius in the west. The famous *Hirundo esculenta*, the constructor of the edible nests of the east, belongs to this genus. The bird which Linnæus so named was unknown to European ornithologists until lately, the species which have been so named having proved not to be the Linnæan species. The description given of it under Swallow-Tribe, E. C. vol. iv. col. 971, is not correct. Rumphius, who was the original describer, states its colour to be mostly black with a bluish reflection, and that it has some white spots on the tail which can only be seen by drawing the tail feathers apart. The erroneous description in the E.C. appears to have originated with Buffon, who gave the name of *Hirundo esculenta* to a bird which had the dusky colouring of a *Collocalia*, but which also had short wings, long legs, and a straight bill; these characters alone suffice to show that the bird he described did not even belong to the *Cypselidæ*. In Buffon's bird the tail feathers were tipped with white. No species of *Collocalia* yet found has that character. There is another curious error relating to this species which has only recently been corrected. Under Swallow-Tribe, E. C., as well as under Algæ, the edible nests are stated to be composed of sea-weeds. They are really formed mainly of the saliva of the birds, which material is used to a greater or less extent in the construction of the nest by many other species of *Cypselidæ*. The salivary glands of *Collocalia* are remarkable for their great development.

Dendrochelidon is found in the same area as *Collocalia*, but its range is less extensive; the limits being the neighbourhood of the Aru islands in one direction, and Ceylon in the other. One species, *D. klecho*, makes a nest like that of *Collocalia*, but much smaller. It is semicircular, attached to the horizontal branch of a tree, the branch itself forming the flat bottom of the nest. The walls, which are very thin, are composed of feathers, bits of bark, &c., cemented by the viscous saliva of the bird. The nest will hold but one egg, and is so small that the bird sits on the branch, and covers the nest with only the end of her belly.

We will now turn to the species of the Neogæic area. All the species of *Cypselus* are confined to the northern part of South America; they are on the whole smaller than their congeners in the Old World. Like them, they make their nest of feathers cemented by a gum-like substance, which is believed to be the saliva of the bird. *Panyptila* frequents the northern portion of the area occupied by *Cypselus*, but also ranges through Central America. Mr. Salvin has described the nest and habits of *P. Sancti-hieronymi*, and we quote his remarks in order that they may be compared with those of other genera. "The nest of this species is composed entirely of the seeds of a plant, secured together and hung from the under surface of an overhanging rock by the saliva of the bird. The whole structure measures two feet two inches in length, and is about six inches in diameter. The entrance is at the end, and the hollow for the eggs at the top. The first time we met with this beautiful swift was near San Gerónimo in Vera Paz, soon after our arrival in Guatemala in 1861. I then recognised it as distinct from *P. melanoleuca;* but afterwards, not having secured specimens, imagined we must have mistaken it for that bird. In July of last year (1862), I had the satisfaction of having brought to me alive, by Mr. Carter of San Gerónimo, two birds which clearly showed that our first impression was correct. They had been caught by an Indian under a rock near the village of Matanzar, in the mountains. The birds, though apparently uninjured, were quite sleepy, not attempting to fly, the only energy they exhibited was by making their powerful claws meet in my fingers when I endeavoured to secure them. I afterwards, on several occasions, observed them flying over the plain with amazing swiftness during dull rainy evenings of July. Later on in the autumn, Mr. Hague, of San Gerónimo, secured for me the nest which I now exhibit. He found it, during a visit to some Indian ruins in the neighbourhood, sticking to the undersurface of an overhanging rock. The bird was distinctly seen to enter several times, but Mr. Hague was unable to shoot it, owing to its rapid flight. There were no eggs in the nest. In this nest we see the saliva of the bird used as an adhesive material in nest building, as in the genus *Collocalia* of the Old World, but differently applied. At first sight the saliva appears to have been used merely to secure the foundation of the nest (if the term may be applied inversely) to the overhanging projection of rock upon which the rest of the structure is woven, as in the nests of the *Icteridæ;* but upon closer examination it will be seen that the saliva has been applied to secure every one of the seeds used in the construction of the nest, and in no other way could so firm and durable a structure be attained. Another curious feature will be noticed in this nest, which is the false entrance at the side. I remember to have seen a similar thing in other nests; I think they were Australian. They appear to be placed there to deceive some enemy, such as a snake or lizard, to the attacks of which the parent bird or its offspring would, during the time of incubation, be more exposed. It would be interesting to know how the materials for the nest were gathered, whether from the plant itself, or caught in the air by the bird as the seeds were carried by the wind." (*Proc. Zool. Soc.* 1863, p. 191.)

Chætura has a wider range than any other American genus. Representations of it are to be found from California and the United States on the north to La Plata on the south. The species are for the most part larger than their congeners in the old world. The largest, *C. semicollaris*, has a total length of ten inches, and has as yet only been found in Mexico. The next in size, *C. zonaris*, is nine inches long. It ranges from La Plata to Guatemala, or about 50 degrees of latitude. Each of the other species spreads over a far less extent of country than *C. zonaris*. The chimney swallow, *C. pelasgia*, is the only species inhabiting the eastern United States. Its mode of nidification has been described by Dr. Brewer in the following terms:—"The nest of the chimney swallow is one of the most remarkable structures of the kind to be found among the handiworks of even this interesting family, nearly all of whom are far from being undistinguished for their architectural accomplishments. It is composed of small twigs of nearly uniform size, which are interwoven into a neat semicircular basket. In selecting the twigs with which to construct the nest, the swift seems to prefer to break from the tree such as are best adapted to its wants, rather than to gather those already upon the ground. This is done with great skill and adroitness while on the wing. Swooping on the coveted twig, somewhat as a hawk rushes at its prey, it parts it at the desired place and bears it off to its nest. This fact is familiar to all who have attentively observed their habits. Each of these twigs is strongly fastened to its fellows by an adhesive saliva secreted by the bird; and the whole structure is as strongly cemented to the side of the chimney in which it is built by means of the same secretion. When dry this saliva hardens into a glue-like substance, apparently firmer even than the twigs themselves. In separating a nest from the chimney I have known portions of the brick to which it was fastened to give way sooner than the cement with which it had been secured." (*N. American Oology*, vol. i. p. 109.)

Cypseloides occurs in Brazil, the West India islands, and British Columbia.

D

DEVONIAN GROUP. [E. C. vol. ii. cols. 320, 321; and OLD RED SANDSTONE, E. C. vol. iv. cols. 78—80.] The term "Devonian Group" was originally applied to the great series of grits, sandstones, slates, and limestones, which occupy the northern portions of West Somerset and Devonshire. It has since been applied to all the foreign strata which are believed to be of the same age, that is intermediate between the Silurian and carboniferous formations. Considering how difficult it is to prove the contemporaneity of strata, we shall prefer to apply this term to all the rocks which were laid down in the period intervening between the above-mentioned formations, so as to make it independent of the precise age of the North Devon rocks themselves.

The rocks of North Devon are the typical representatives of the Devonian group; and if Professor Jukes's suggestion be accepted that these strata are simply old red sandstone and carboniferous slates, doubts will be entertained by some as to the Devonian age of the foreign strata which are usually considered to belong to this period.

Before, however, making any further allusion to Professor Jukes's opinions, we will endeavour to indicate the facts upon which is based the conclusion that the rocks of North and South Devon represent a special period of time.

According to the most generally received opinions the rocks of North Devon follow one another conformably, that is, without any break in the stratigraphical succession from the lowest beds at the Foreland and Lynton on the north coast to the lowest carboniferous beds south of Barnstaple. In this area the upper Devonian pass into the carboniferous system, but as we are ignorant what connection the Lynton beds have with the rocks beneath, no idea can be formed from stratigraphical considerations only as to whether the Devonian series passes conformably into the Silurian group at moderate or great depths below the horizon of the Lynton sandstone, or whether there may not be a great thickness of rock below this horizon, and even then an unconformability between the lowest Devonians and highest Silurians. As the uppermost connection is manifest while the lowermost is unknown, caution should induce us to place the Lynton sandstone as high as possible consistent with the nature of the strata and the character of the organic remains in the overlying slates. The general strike of the Devonian strata is N.N.W. and S.S.E., and the average dip is south and a little to the west of south; so that in passing from north to south we traverse the outcrops in an ascending order. The same succession presents itself in going from Porlock directly south, as in following the coast line from Porlock to Bideford Bay; but the sections are best displayed along the coast. The lowest Devonian beds known are the sandstones which occupy the country from the North Foreland to the Quantock Hills, but it is covered in places by the new red sandstone. The lowest strata are exposed at the north-west side of the Quantock Hills, and near Minehead. In the Minehead district they are coarse red, grey, pale yellow, and mottled, thick bedded sandstone, interstratified with fine grained flaggy beds, which have a general dip to the north-east. At Lower Hopcote they still have a north-easterly dip, and consist, at this place, of massive beds of red and grey crystalline grits, which are much jointed and are parted by falsely bedded clayey shale. In lithological details these beds are more like the old red sandstone of Scotland and Wales than others in Devonshire; but no organic remains have been found in them. The north-easterly dip is general amongst these lowest beds, but towards the south they are either arched over by an anticlinal, or faulted so as to have a north-westerly dip. The point where the change of dip occurs is hidden by triassic sandstones and conglomerates; but it is in a line with the faults which run east and west past St. Decuman, Watchet, Quantock's Head, and Little Stoke. These strata form the Lynton sandstone; and are noticeable for having a splintery fracture, and for breaking up into very small cubical fragments, in which respects it differs from the usual character of the old red sandstone. All the high land about Porlock is composed of these hard sandstones. The actual junction of the Lynton sandstone with the next succeeding group, the Lynton slates, does not seem to have been observed; but as the dip of the slates is conformable with that of the sandstones in many places, it is presumed that there is no fault or break. At Foreland the lower slates are much disturbed. The Lynton slates are about 1500 feet thick, and have a gentle dip towards the south. Their junction with the Hangman grits above may be seen at Woodabay, Heddonmouth, and other places. The slates are interbedded here and there with calcareous nodules, in which many of the fossils of this group occur. The gritty character of the slates and limestones, and the general distribution of ripple marks and false bedding indicate that these strata were deposited in a shallow rather than a deep sea. The calcareous matter prevails most towards the lower portion of the Lynton slates. The fossils are generally distributed, but are not very abundant in species, although some of the beds may be crowded with individuals of one species. Thus *Orthis arcuata* occurs in extreme profusion at Watersmeet, Lynton, and many other localities.

Etheridge records fifteen species from these slates; the most characteristic of which are *Fenestella antiqua, Megalodon cucullatum, Orthis arcuata, Orthis granulosa, Spirifera lævicosta, Pleurotomaria aspera,* and *Bellerophon globatus.*

The Hangman grits are a series of red sandstones, from 1500 to 2000 feet thick, which are exposed along a belt of country about three miles wide, from Trentishoe on the west to Croydon Hill on the east, or along a strike of about 30 miles. As already noticed, they are conformable with the Lynton slates below, and they are also conformable with and graduate into the calcareous slates of the Ilfracombe series above, as may be seen at Combe-Martin Bay, and in the neighbourhood of Oaktrow. Thus at Oaktrow the grits are fissile, and separated by slaty partings. Between Oaktrow and Ashwell the slates thicken at the expense of the sandstones, and at Catcombe the grits are absent, the strata being entirely composed of slate. In going still farther south, the slates become more and more calcareous, until at Wheddon Cross and many places in the same line of strike, thick bands of limestone are met with containing the characteristic fauna of the Ilfracombe series. Advancing still south, the beds retain the usual southerly dip, the limestones die out, and the beds become formed of a grey glossy slate, the Morthoe slates. The fossils of the Hangman grits are few, and confined to casts of *Myalinæ, Naticæ,* and a few other forms. The slates which succeed abound in *Stringocephalus Burtini,* and hence are sometimes called the *Stringocephalus* slates. The calcareous slates which follow next have yielded many fossils, most of which are, however, confined to the limestones. The limestones occur in two series in the middle part of the calcareous slates, which are about 1000 feet apart. As the typical localities for the middle Devonian fossils are grouped round Combe Martin, Watermouth, Hagginton, and Ilfracombe, we will quote Mr. Etheridge's description of them:—"At Watermouth, which is in a direct line (on the strike) with the main mass of the shales, slates, and lower limestones of Combe Martin, many good sections occur, both in old quarries and on the coast. The shales, slates, and sandstones, which alternate here, are remarkable for their diversity of character, yet continuing with the same conditions repeated round Widmouth Head to Hagginton Beach. Quartz veins with lead I know nowhere else. At Sandaby, masses of siliceous rocks, containing *Stringocephalus Burtini* (Defr.), occur; and Mr. Valpy has obtained *Trimerocephalus lævis* (Münst.), from mottled grey and red shaly rocks which overlie the stringocephalic grits, associated with *Spirifera disjuncta* (Sow.), *Atrypa reticularis* (Lin.), and its variety, *A. aspera* (Schloth.), *Rhynchonella pleurodon* (?), *Fenestella,* &c. The Widmouth series at its lowest part consists of finely laminated, thick-bedded sandstones, with *Tentaculites scalaris* (Schloth.), and casts of other fossils. Above this tentaculite sandstone succeeds a considerable seam of red sandstones, in which no organic remains occur; an irregular mass of dark limestones, with corals, especially *Favosites cervicornis* (Blainv.), *Stromatopora,* and obscure masses of *Cyathophyllum cæspitosum* (Goldf.), overlies the red grits. Mr. Valpy informs me that on this limestone thin shales occur which are studded with carbonaceous nodules and coprolites of fish. Succeeding the Widmouth rocks, and higher in the series, are the Rillage and Hagginton beds. I examined the latter only; but a glance at them convinced me that patient and long study only could enable anyone to make out the details of the complicated structure of the rock masses of Hagginton Beach. The history of the Ilfracombe group is, indeed, written in the coast series from Combe Martin Bay to Ilfracombe, but particularly so in the fine section of slates, sandstone, shaly limestone, and grits of Hagginton Beach and the Hill quarries, the impure clayey limestones, and quartzose sandstones, &c., on the coast, and Hagginton Hill quarry having yielded upwards of 30 species, 20 of which belong to the Brachiopoda." The series of beds from the Hangman grits to the Mortehoe slates inclusive have yielded upwards of 70 species, which constitute a well-marked and distinctive fauna. The Mortehoe slates pass into the series above it, or the Pickwell Down sandstones, without any disturbance. Professor Jukes's views as to the stratigraphical relation of the Devonian strata mainly depend upon the supposed existence of a great fault between the Mortehoe slates and Pickwell Down sandstones, with a downthrow on the north of thousands of feet. We append Mr. Etheridge's facts in favour of their conformability:—"I have now to show, if possible, that there is no unconformity in Morte Bay between the Mortehoe and Woolacombe slates, and the Pickwell Down sandstones, and, that they here insensibly, through lithological changes, graduate into the hard red grits and sandstones at Potter's Hill, Croscombe, and Pickwell Down, as they do at Wiveliscombe and intermediate points. Up to the village of Woolacombe, north of the stream, the slates are seen in places on the shore under Tracey and Potter's Hill, dipping 60° and 70° S. The Woolacombe and Osborough valley was carefully searched; and nowhere down the stream, which here runs over and cuts through the strike of the beds, or to the east at Dean Mill, where they are cut across by another rivulet, and dip 70° S., did I detect any inversion, notable disturbance, or alteration; more than that, the gradation into the thicker beds of Potter's Hill and Higher Buller is traced through a series of red gritty slates and fissile sandstones, dipping 50° S., and resembling in all particulars the junction at and passage under Main Down, west of Wiveliscombe, &c.; the small quarry on Potter's Hill showed the same lower thin-bedded red grits dipping 45° S.; on the strike of these beds, east, across the hill, and in a quarry at Higher Buller, the same series dip 60° S. Descending to the shore under Potter's Hill and at Tracey, we now take them in upward succession; the reefs of grey fissile slates, with rusty or decomposed bands, that crop out on the shore immediately west of the kiln at Woolacombe, are the same that occur in the Tracey and Osborough valley, and are immediately succeeded by the Potter's Hill red group. On and along the shore between Woolacombe and Baggy Point twelve groups or reefs of red, claret, grey, and green micaceous sandstones crop up, and the recent marine sands of Morte Bay (Woolacombe Sands) cover up their inclined edges and continuous dip. Every bed visible along the shore, and composing this series of sandstones, was measured, the interspaces (covered by the sands) were paced, and careful notes made upon the whole magnificent section up to the overhanging abrupt northern face and escarpment of Baggy Point, where, without a trace of movement, break, or unconformity, the passage into the true fossiliferous Upper Devonians is complete. It is both superfluous and unnecessary to describe the Morte section in detail; it speaks for itself; neither above or at the top of the upper old red sandstone at Vention and Peelsborough, nor at the base at Tracey or Osborough is there any evidence of dislocation, or any trace of a fault." The calcareous slate series has an estimated thickness of about 8000 feet, and the Mortehoe slates are at least 4000 feet. Hence the whole thickness of the beds, from the base of the Hangman grits to the base of the Pickwell Down sandstones is about 14,000 feet.

Above the Pickwell Down sandstones, which are unfossiliferous, there is first a band of pale, nearly white, slate, containing a few bivalves, followed by a thick series of greenish grey grits, with bands of *Cucullæa* and *Avicula Damnoniensis,* and beds of olive or greenish shale, in which a few plant remains are met with, as well as abundance of *Lingula squamiformis* (*L. mola,* Salter). These are the Marwood beds of Mr. Salter, and the Baggy and Marwood slates, Croydon beds, and Braunton beds of Mr. Etheridge. Overlying these is an alternating series of calcareous sandstones, grey shales, with thin nodular bands of limestone, and grey fossiliferous slate, more or less cleared, and which in the aggregate measure many hundreds of feet. It represents the Pilton group. The grey slates and finely laminated sandstone make up the bulk of the group. The sandstone is generally calcareous, but in places it is really an oolitic limestone. The fossils which are characteristic, or most abundant in those beds, are *Avicula Damnoniensis, Strophalosia productoides, Spirifera disjuncta, Sp. barumensis, Productus prælongus, Orthis interlineata;* together with species of *Curtonotus, Actinocrinus, Poteriocrinus,* and *Rhodocrinus.* There are also numerous black phosphatic nodules. South of the Pilton series come the Barnstaple beds, which contain a large proportion of the carboniferous fossils, and which Mr. Salter correlates with the true carboniferous slate of Ireland. Still farther south are the culm measures, the carboniferous limestone, and the millstone grit, all of which unquestionably belong to the carboniferous formation, and which in places are seen to rest unconformably upon the upturned edges of the Devonian strata.

These data, then, seem to prove that the Devonian strata are conformable from top to bottom, and are older than the Carboniferous formation; that there is an alternation of reddish sandstones, containing few or no fossils, with slates, shales, and limestones, which, for the most part, abound in fossils; that there is a resemblance in some general features between the sandstones, slates, limestones, &c., at different horizons, which might induce some to suspect that they were repetitions of one another; but a closer examination reveals details which seem to disprove rather than confirm such a supposition. Professor Jukes's view is that the Lynton sandstone is equivalent to old red sandstone; that it is overlain by the strata which are mentioned above on the Lynton slates, Hangman grits, the Ilfracombe calcareous slates, and the Mortehoe slates, and which he considers to be the representatives of the carboniferous slates of Ireland. The upper limit of the Mortehoe slates, he believes, is marked by a fault which has depressed the strata to such an extent as to bring the Mortehoe slates on a level with the Pickwell Down sandstone, which he regards as a repetition of the Lynton sandstone; while the strata from the Baggy slates to the Barnstaple beds are repetitions of those from the Lynton to the Mortehoe slates. There is, however, no proof of a fault, nor of an anticlinal, such as the nature of the case would demand; and the lithological structure of the strata does not accord with the view of their being repeated, for the Lynton sandstone is very different from the Pickwell Down sandstone; the Lynton slates are markedly distinct from the Baggy and Marwood slates; the Hangman grits are readily distinguishable from the Braunton beds, and there is nothing whatever in North Devon, on the south side of the supposed fault, to correspond with the calcareous slates and Mortehoe slates, which are so well developed to the north of it.

The palæontological evidence is still more decisive against Professor Jukes's views. This will appear from the following list given by Mr. Etheridge, in which the species from the Lynton slates are grouped as Lower Devonian; those from the Hangman grits and calcareous slates as Middle Devonian; and those from the strata above the Mortehoe slates as Upper Devonian.

- Lower Devonian.
    - Alveolites suborbicularis. Lam.
    - Favosites cervicornis. Blainv.
    - Petraia pleuriradialis. Phill.
    - Actinocrinus tenuistriatus. Phill.
    - Fenestella antiqua. Goldf.
    - Chonetes Hardrensis. Phill.
    - Orthis arcuata. Phill.
    - Orthis granulosa. Phill.
    - Spirifera annulifera. Valen.
    - S. hysterica. Schlott.
    - S. lævicosta. Valen.
    - Streptorhynchus umbraculum. Schlott.
    - Pterinea spinosa. Phill.
    - Ctenodonta Krachtæ. Roen.
    - Megalodon cucullatum. Sow.
    - Pleurotomaria aspera. Sow.
    - Bellerophon striatus. Bronn.
- Middle Devonian.
    - Stromatopora concentrica. Goldf.
    - Amplexus tortuosus. Phill.
    - Cyathophyllum æquiseptum. Edw.
    - C. boloniense. Blainv.
    - C. cæspitosum. Goldf.
    - C. helianthoides. Goldf.
    - C. obtortum. Edw.
    - Cystiphyllum vesiculosum. Goldf.
    - Favosites cervicornis. Blainv.
    - F. dubia. Blainv.
    - F. fibrosa? Goldf.
    - Hallia Pengellyi. Edw.
    - Heliolites porosa. Goldf.
    - Heliophyllum Hallii. Edw.
    - Pachyphyllum devoniense. Edw.
    - Cyathocrinus macrodactylus.
    - C. variabilis. Phill.
    - Tentaculites annulatus? Schloth.
    - T. scalaris. Schloth.
    - Phacops (Trinerocephalus) lævis. Münst.
    - Ceriopora similis. Phill.
    - Fenestella antiqua. Goldf.
    - F. arthritica. Phill.
    - Glauconome sp.
    - Retepora repistria. Goldf.
    - Athyris concentrica. V. Buch.
    - A. lachryma? Sow.
    - Atrypa desquamata. Sow.
    - A. reticularis. Linn.
    - A. reticularis, var. aspera. Schloth.
    - Cyrtina heteroclyta. Defr.
    - Merista plebeia. Sow.
    - Orthis interlineata. Sow.
    - O. striatula. Schloth.
    - Rensselæria stringiceps. Roem.
    - Rhynchonella cuboides. Sow.
    - R. pleurodon. Phill.
    - R. pugnus. Mart.
    - Spirifera canalifera. Valcn.
    - S. curvata. Schloth.
    - S. disjuncta. Sow.
    - S. nuda. Sow.
    - S. speciosa. Schloth.
    - Stringocephalus Burtini. Defr.
    - Streptorhynchus crenistria. Phill.
    - S. umbraculum. Schloth.
    - Strophomena rhomboidalis. Wahl.
    - ? Megalodon cucullatum. Sow.
    - Schizodus deltoideus. Phill.
    - Myalina sp.
    - Acroculia vetusta. Sow.
    - Euomphalus radiatus. Phill.
    - E. serpens. Phill.
    - Macrocheilus brevis. Sow.
    - Natica meridionalis. Phillips.
    - Bellerophon bisculcatus. Roem.
    - Conularia sp.
    - ? Orthoceras cylindraceum. Sow.
    - Orthoceras cylindricum. Sow.
    - O. tentaculare. Phill.
    - Fish remains.
- Upper Devonian.
    - Knorria dichotoma. Haught.
    - Adiantites Hibernicus. Forbes.
    - Sagenaria veltheimiana. Sternb.
    - Bornia transitionis. Göpp.
    - ? Amplexus tortuosus. Phill.
    - Fistulipora cribrosa. Goldf.
    - ? Michelinia antiqua. McCoy.
    - Petraia Celtica? Lonsd.
    - P. pleuriradialis. Phill.
    - Actinocrinus tenuistriatus. Phill.
    - A. triacontadactylus? Müll.
    - Adelocrinus hystrix. Phill.
    - Cyathocrinus macrodactylus.
    - C. pinnatus. Goldf.
    - C. variabilis. Phill.
    - Pentremites ovalis. Goldf.
    - Taxocrinus macrodactylus. Phill.
    - Phacops granulatus. Münst.
    - P. latifrons. Bronn.
    - P. (Trimerocephalus) lævis. Münst.
    - ? Ceriopora similis. Phill.
    - C. gracilis. Phill.
    - Fenestella antiqua. Goldf.
    - F. plebeia. McCoy.
    - Glauconome bipinnata. Phill.
    - Polypora laxa. Phill.
    - Athyris concentrica. V. Buch.
    - A. decussata. Sow.
    - ? A. indentata. Sow.
    - A. oblonga. Sow.
    - ? Atrypa desquamata. Sow.
    - Chonetes Hardrensis. Phill.
    - Discina nitida. Phill.
    - Lingula squamiformis. Phill.
    - Orthis interlineata. Sow.
    - O. striatula. Schloth.
    - ? Productus longispinus. Dav.
    - P. prælongus. Sow.
    - P. scabriculus. Mait.
    - Rhynchonella laticosta. Phill.
    - R. pleurodon. Phill.
    - R. pugnus. Mait.
    - R. reniformis. Sow.
    - Spirifera disjuncta. Sow.
    - S. lineata. Mart.
    - S. megaloba. Hall.
    - S. mesomala. Phill.
    - S. obliterata. Phill.
    - S. rudis. Phill.
    - S. Urii. Fleming.
    - Spiriferina cristata. Schloth.
    - Streptorhynchus crenistria. Phill.
    - S. plicata. Sow.
    - S. semicircularis. Phill.
    - Strophalosia productoides. Murch.
    - Strophomena rhomboidalis. Wahl.
    - Terebratula elongata? Schloth.
    - T. sacculus. Mart.
    - Avicula Damnoniensis. Sow.
    - A. subradiata. Phill.
    - Aviculopecten nexilis. Sow.
    - A. polytrichus. Phill.
    - A. transversus. Sow.
    - Pterinea cancellata. Phill.
    - P. reticulata. Phill.
    - P. rudis. Phill.
    - ? Clidophorus ovatus. Sow.
    - Cucullæa amygdalina. Phill.
    - C. augusta. Sow.
    - C. complanata. Phill.
    - C. depressa. Phill.
    - Cucullæa Hardingii var. Sow.
    - C. trapezium. Sow.
    - Ctenodonta latissima. Phill.
    - C. lineata. Phill.
    - C. plicata. Phill.
    - C. pullastriformis. McCoy.
    - C. antiqua.
    - Curtonotus unio. Salt.

C. elegans. Salt.
Cypricardia Phillipsii. D'Orb.
Leptodomus constrictus. M'Coy.
Sanguinolaria elliptica. Phill.
S. (Edmondia) sulcata. Münst.
Sanguinolites complanatus. Phill.
S. liratus. Phill.
Acroculia vetusta. Sow.
Euomphalus serpens. Phill.
Loxonema rugifera. Phill.
Macrocheilus neglectus. Phill.
Murchisonia angulata. Phill.
Natica meridionalis. Phill.
Pleurotomaria aspera. Sow.
P. cancellata. Phill.
P. expansa. Phill.
P. gracilis. Phill.
Bellerophon bisculcatus. Roem.
B. subglobatus. M'Coy.
B. Urii. Fleming.
Porcellia Symondsii.
Goniatites vinctus. Sow.
? Orthoceras cinctum. Sow.
O. cylindraceum. Sow.
O. imbricatum ? Wahl.
O. lineolatum. Phill.
O. ludense ?
O. tentaculare. Phill.
O. undulatum.
O. striatum.
Holoptychius sp.

According to these lists there are 14 genera and 17 species known from the Lower Devonian; 38 genera and 59 species from the Middle Devonian; and 55 genera and 110 species from the Upper Devonian. The palæontological relations between these groups will be seen from the following summary, in which the percentages are so calculated as to obviate as much as possible the misconception liable to arise from paucity and inequality in the number of species. One example will illustrate what we mean. If only a few species were known from the Lower Devonian, and these species were to recur in the Middle Devonian, associated with upwards of 50 other species, it would not represent the probable closeness of the connection to say that all the Lower Devonian species pass up into the Middle Devonian. A more approximate idea will be obtained by calculating the percentage common to both periods upon the numbers present in each division, and dividing by two; and this is what we have done. For instance, 5 species, or 39 per cent. of the Lower Devonian species, pass up into the Middle Devonian strata, of the fauna of which they constitute rather more than 8 per cent. These numbers added together and divided by 2 yield 23 per cent., which represents the approximate palæontological degree of affinity between the two faunas. Of the 17 Lower Devonian species, 5 pass into the Upper Devonian, and the affinity between the two faunas is 21 per cent. Of the Middle Devonian species 20 pass into the Upper Devonian, the affinity between the two faunas being 26 per cent. One or two species in the Lynton beds, or Lower Devonian, is known in the carboniferous limestone; but even this point is doubtful, for it is not certain that the *Chonetes hardrensis* of the Lower Devonian is specifically the same as the *Chonetes hardrensis* of the carboniferous formation; and *Fenestella antiqua* is a fossil that cannot be relied on, since it generally occurs in casts. The palæontological evidence then, as far as it goes, confirms the distinctness of the Lower, Middle, and Upper Devonian groups, and discountenances the view that the Lower and Upper are formed of the same strata. Moreover, it shows decidedly that the Ilfracombe series is not a part of the carboniferous formation, since less than 9 per cent. of the Middle Devonian fossils pass into that formation in other areas.

If, then, it be admitted that the so-called Devonian strata were deposited after the Silurian, and before any of the carboniferous rocks, it would seem probable that they might be, either wholly or in part, synchronous with the old red sandstone, which occupies a similar stratigraphical position. Many geologists have written in support of the view that Lower, Middle, and Upper Old Red Sandstone, correspond with the Lower, Middle, and Upper Devonian. Thus, Mr. Salter has described how the upper old red of Pembrokeshire consists almost entirely of red sandstone and marl north of West Angle Bay, there being only a few grey sandstones and subcalcareous bands. Farther south the red sandstones diminish, and are replaced by fossiliferous limestones and grey shales. The fossils comprise *Serpula advena*, *Avicula damnoniensis*, *Cucullæa trapezium* (?), *Rhynchonella laticosta*, *Bellerophon bisculcatus*; as also species of *Pleurotomaria*, *Nucula*, *Sanguinolites*, *Modiola*, *Axinus*, and *Discina*; many of which are characteristic of the Upper Devonian of North Devon. On passing into North Devon, the grey shales and limestones present a still greater development, while the red sandstone has almost disappeared. There are several plants which have as yet only been found in the upper division of the Old Red Sandstone, and of the Devonian of North Devon, viz., *Knorria dichotoma*, *Adiantites hibernica*, *Sagenaria veltheimiana*, and *Bornia transitionis*. The evidence is scanty, but it all points in one direction, and is confirmatory of that which is yielded by the Devonians of other areas.

A comparison of the Devonians of North Devon with those of other countries suggests a question to which there is great difficulty in giving a satisfactory solution. Granting the possibility of distinguishing the Lower, Middle, and Upper Devonian throughout western Europe generally, can it be safely asserted that the three divisions are synchronous amongst themselves? For instance, taking Mr. Etheridge's general table as a standard, and the brachiopodous faunas as the test of comparison, we obtain, by applying the percentage method indicated above, results which show that, as far as the brachiopoda is concerned, there is sometimes a closer affinity between the Lower Devonian of one area and the Middle Devonian of another area, than between the Lower Devonian of the two areas. Thus the Lower Devonian of North Devon has a relationship of 56 per cent. with that of Cornwall; 32 per cent. with that of Belgium; 24 per cent. with that of the Rhenish district, and only 17 per cent. with that of South Devon. The same division in North Devon has a relationship of 38 per cent. with the Middle Devonian of South Devon; 33 per cent. with that of the Rhine; 23 per cent. with that of Cornwall; 21 per cent. with that of France; 19 per cent. with that of North Devon, and 18 per cent. with that of Belgium. Its relationship with the Upper Devonian of North Devon is 6 per cent., and none of the species occur in the Upper Devonian and other areas in western Europe. The prominent feature here is that while the relationship between the Lower Devonians of North and South Devon is only 17 per cent., that between the Lower Devonian of North Devon and the Middle Devonian of South Devon is 38 per cent. These figures afford no clue as to whether the facts on which they are based are more in favour of the South Devonian strata being older or later than those of North Devon. This can only be ascertained by analyzing the lists, and for the present we will restrict our attention to Devonshire. Of the five species from South Devon there are two species which are known only in the Lower Devonians of the county, but neither of these occur in North Devon. Of the eight species which ascend into the Middle Devonian of South Devon, one is known in the Lower Devonian only of North Devon, and two others occur in the Middle Devonian of that area. One species occurs in the Upper Devonian of North Devon. From this it would appear that the Lower Devonian fossiliferous strata of South Devon are older than those of North Devon. Of the seven species from North Devon only one is peculiar to the Lower Devonian of that area. There is also only one which occurs in the Lower Devonian of North Devon, whereas four species occur in the Middle Devonian of North Devon. Relying simply upon this evidence the strata should be arranged thus, the first mentioned being the oldest: Lower Devonian of South Devon, Lower Devonian of North Devon, Middle Devonian of North Devon, Middle Devonian of South Devon. These remarks, of course, only apply to the faunas, which are restricted to a portion only of the strata. The relationship between the two Middle Devonians is 61 per cent. We shall have occasion to allude to this again in describing the strata of South Devon. The connection of the Middle Devonian of North Devon is closest with that of South Devon, after which follows that of the Rhenish district (54 per cent.), while the connection with that of Cornwall is 32 per cent.; it has an affinity of 31 per cent. with the Lower Devonian of the Rhine; 51 per cent. with the Upper Devonian of the Rhine; 39 per cent. with the Upper Devonian of Cornwall; 38 per cent. with the Upper Devonian of Belgium, and 35 per cent. with that of North Devon. An analysis of the Middle Devonian brachiopoda of Devonshire confirms the indication suggested by the distribution of the Lower Devonian, since a larger proportion of the North Devon than of the South Devon species pass into higher strata.

Passing next to the area of South Devon and Cornwall we will endeavour, by the aid of Dr. Holl's paper ('Q. J. Geol. Soc.' vol. xxiv.), to indicate the probable succession of strata, and to point out what appears to be their probable correlation with the strata of North Devon. The general strike is nearly east and west, but with a curve towards the north at the eastern end of the district, as in the neighbourhood of Ashburton and Newton Bushel. The country is much faulted and undulated, so that it is difficult to ascertain convincingly the true succession of the strata. The dips are usually N.E. and S.W. or S.E., but the prevalent dip appears to be southerly, since the younger rocks are most developed in the south and the older ones in the north. The latter part of this remark is liable to some modification, since some of the oldest strata are brought up to view towards the extreme south in the arches of anticlinal folds. It is in consequence of the faulted, folded, and denuded condition of the strata that there is a somewhat sporadic distribution of the strata of the same horizon; and as there are no prominently conspicuous differences between the higher and lower beds, it is not easy to distinguish between them in the absence of direct stratigraphical evidence. On these grounds we shall mainly follow the order in which Dr. Holl mentions the strata before attempting to indicate what the general succession is. On the western side of the Dartmoor granite, and a little south of Tavistock, the beds are pale greenish and grey argillaceous slates intersected by numerous veins of quartz, and interstratified with a few beds of grits, the prevailing dip being south-west. They range as far south as Beer Ferris and Bickleigh, and pass under higher beds of slates, many of them blue and purple, near Tamerton Foliot. The country west of the Tamer is much faulted, and the southern limit of this expanse of green and grey slates is near Callington. Associated with the green and grey slates are a number of elvans which have the same strike, but not the same dip, as the slates themselves. There are also numerous beds of volcanic ash which are contemporaneous with the slates, since all have the same dip, the same strike, and the same plane of bedding. Farther north, as at Trewen, the slates and ash beds dip N.E., and pass under fossiliferous slates in the midst of which are developed the limestones of Petherwin and Landlake. This would indicate an anticlinal disposition of the strata; the axis passing from Buckland Monachorum, near the granite of Dartmoor, westwardly into the east part of Cornwall. The blue and purple slates near Tamerton Foliot would then be on nearly the same horizon as the upper slates near Trewen; and the Petherwin limestone in the north would correspond to the Plymouth limestone in the south. The Trewen or upper slates are chiefly olive and brownish, speckled and stained with ochreous matter, much cleaved and of a splintery fracture in their lower portions; but the higher beds, north of Trewen, are softer, thicker, paler, and more even in texture. They are unconformably overlain by the culm measures of Central Devon. The Trewen or upper slates, are also associated with volcanic beds which range nearly as high as the limestone. Farther westward, or in Cornwall, greenish-grey slates dip under a band of volcanic rock at Penhall and St. Kitt's, and are underlain by lower rocks with their grits. Still farther west, as at Delabole, Tregalla, and Tintagell, there are greyish slates beneath volcanic beds, which have a general dip to the south and south-west. They dip under the higher slates of Delamere Down, which appear to correspond to the higher slates north of Trewen, but they differ in being free from interstratified beds of volcanic ash. This, however, only applies to the lower part of the series, for farther westward, or near St. Teath, higher beds come in, and those are not only associated with ash beds, but also with calcareous bands which appear to correspond in position with the Petherwin limestone. These limestone bands can be traced from Constantine Bay, by Padstow and St. Michael's to Lower Amble, while some of the slates associated with them are purple, and similar to those of Saltash and St. Germans. Along St. Breock's Down is an east and west anticlinal axis which extends from near Morgan Porth to near Polbroke, which brings up lower rocks consisting mainly of pale slates interstratified with bands of grey grit and much intersected by quartz veins. Similar beds form a narrow strip of country in the vicinity of Boconnock and Broadoak, and it is probable that the grits near St. Keyne are an eastern extension of them. The St. Keyne grits pass under the argillaceous and calcareous rocks on the south.

Returning again to the south-eastern corner of Cornwall, the argillaceous rocks with volcanic beds south of St. Looe are so highly plicated and cleaved that it is difficult to trace their relation with other strata, or to ascertain their thickness. At Quethiock they dip south, reappear at Menheniot, and further south are succeeded by slates which are sometimes purplish. Still further south we come upon the grey, blue, and purple slates near Landrake; and these are succeeded by the slates and volcanic beds of St. Stephen's and Saltash. These latter slates dip south and pass under the blue and purple slates with ash beds which lead up to the Plymouth limestone. On the west side of the Hamoaze the variegated slates, with their grits at Grafthole, are succeeded by the grey slates of Polscove, and these by the grits of Sheviock. At St. Looe, also, there are similar slates with underlying grits. This succession of the strata from the purple slates to the grits is strikingly similar to what we have already indicated to be the downward succession, and there is apparently nothing in the structure of the country to disprove this supposition. There is probably an anticlinal or a fault which causes the apparent inversion of the beds in this district. On the east side of the Hamoaze there is little doubt that the succession of the beds is upward as we pass from north to south. The argillaceous slates with ash beds of Landrake are on the same strike as those at Tamerton Foliot, and there, as has already been stated, they are overlain by the Plymouth limestone, and this in its turn is overlain by the grey and blue slaty rocks of Mount Edgcumbe, Plimstock, and Elberton. In following up the line of strike towards the east we come upon a series of limestone scattered over a wide expanse of country, and most developed in the extreme east, as at Ashburton, Newton Bushel, and Torquay. Smaller masses occur at numerous other localities. It is generally supposed that these limestones are on the same horizon and are repeated by undulations and faults; but there are a few facts which would lead one to infer that they represent two series of limestones situated at different horizons. Dr. Holl seems to be inclined to take this view of the matter, and as it would be impracticable to discuss it without entering into minute details, we quote his general remarks on the subject. "It is obvious that the true position of the Plymouth and Torbay limestones in the general mass of the South Devon rocks, is a matter of great importance to the correct interpretation of the structure of the country. Looking at the rock, the question might suggest itself whether or not the limestones which range by Bickington and Ashburton to Dean Prior might not be the same as those of Ogwell, Ipplepen, and Dartington, thrown over a broad anticlinal axis of the lower slates to the north-west. This view, no doubt, would have the merit of simplifying the structure of the country south of the culm measures, inasmuch as it would bring the limestones of South Petherwin, Padstow, the Looe river, and St. Germans, into relationship with those of Plymouth and Torbay on one horizon; and, as will be shown hereafter, although the distribution of organic life in these rocks is very irregular and local, nevertheless palæontological records would not altogether discountenance it. But however plausible this interpretation may appear at first sight, all the direct evidence obtainable, as already stated, is entirely against it; and whether we cross the country from Bickington, by Hobbs's Wood, to Chircombe Bridge; or from Ashburton, by Woodland, to Torbryan; or farther to the south, from the granite by South Brent to Black Hall, near North Hewish, we appear to have a clear upward succession of the beds; and in the two or three instances in which the volcanic rocks were observed to have exerted any influence on the contiguous slates, it was on the Ashburton slate only. There is equal difficulty in regarding the Plymouth limestone as the same as those of Nulladon and the Looe river brought up to the surface by an anticlinal axis, with the intervening beds troughed in between them, notwithstanding the apparently horizontal throwing out of the limestone at each extremity, and the contortion seen at St. John's. This view would of course require the beds contained in the synclinal trough west of the Looe river, as they trended up to the Lybner and the Hamoaze, to become inverted, and in this position to range eastward to the granite north of Ivy Bridge, where, partly by granite and partly by faults, the continuity of the belt of rocks becomes destroyed. But we cannot assume this view without doing violence to the apparent relations of the bedding on either side of the mouth of the Seaton river, and there is, in fact, no direct evidence to bear it out. Moreover, it would bring these beds into relationship with the rocks which certainly overlie the limestones of Plymouth and Brixham on the south, and occupy the whole of the Dartmouth and Kingsbridge district, with which, notwithstanding a considerable resemblance in lithological character, there is no palæontological evidence to connect them; whereas the rocks which are seen beneath the limestones at Mudstone Bay and Meadfoot sands are related to them by similarity of fossil contents and more especially by their fish remains. On the other hand, the slates which occupy the country between the Ogwell and Ashburton limestones resemble, both petrologically and in the abundant association of volcanic rocks, the beds which, brought down from the Liskeard district by St. Germans and Saltash, and from the coast by Polbathick and by Anthony, are continued by Plympton to the southern extremity of the granite at Ivy Bridge."

Above the limestones at Dartington, Berry Pomeroy, and Marldon, are a series of coloured slates, which are usually claret-coloured in the lower portion, but are more generally grey and dark blue in the higher beds. In places the slates contain bands of grey, yellow, or purplish grit. Their thickness has not been ascertained, but they have a general south-east dip. There is apparently an almost entire absence of calcareous matter, very few organic remains, and many of the beds have a remarkably glossy appearance. These slates appear to be arranged in a series of folds with the tops planed off, and having a uniformly southerly dip. In tracing them from Ugborough on the north to Charleton on the south, the grits thin out, while the slates increase in thickness.

We have yet to notice an exposure of the grits beneath the limestone at Meadfoot sands, which have yielded many of the species found in the grits at Looe, and which appear to be the equivalents of those grits as well as of those brought up by the anticlinal axis of St. Breock's Down. Amongst the fossils found here are *Pleurodictyum problematicum, Athyris concentrica, Spiriferina cristata, Leptæna laticosta, Orthis hipparionyx, Bellerophon bisulcatus*, and *Phyllolepis concentrica.*

In summing up the general conclusions as to the succession of the beds in South Devon and Cornwall, it would seem that the lowest are pale grey slates, interstratified more or less extensively with grits; then follow blue, purple, and variegated slates, which are associated with numerous ash beds, and with at least one, more probably two, horizons at which limestone is developed; and above these follow a series of red grits and slates, together with another series of slates which are grey, blue, green, &c., somewhat glossy, interstratified with a few beds of grits and ash, and poor in fossils. Moreover, they appear to be arranged on either side of an anticlinal axis, which passes from Buckland Monachorum far away into Cornwall, but this disposition is much obscured by faults, undulations, and denudations. It may be noticed, also, that the grits and coarse-grained rocks are, on the whole, best represented towards the west, and the limestones and finer shales are in fullest force towards the eastern end of the area.

This succession, it may be observed, bears a strong resemblance to that of the Middle Devonian beds of North Devon, from the Hangman grits to the Mortehoe slates. Thus the grey slates with grits of St. Breock's Down, Looe, and Meadfoot, correspond to the uppermost portion of the Hangman grits, but differ in being far more abundant in fossils; next follow the pale slates with grits of Buckland Monachorum and elsewhere, which correspond with the lowest portion of the calcareous rocks of the Ilfracombe series; the purple and blue slates of Tamerton Foliot answer to the lower Ilfracombe slates; the ash beds seem to represent the igneous rocks interbedded with the slates of Paracombe in Somersetshire, not far above their junction with the Hangman grits. The limestones of South Devon resemble those of North Devon and Somerset in that they are thickest towards the east, and probably also in being met with at two horizons, since this is known to be the case in Somerset, and there are some grounds for believing it also to be the case in South Devon; the higher volcanic ash beds of North Devon appear to represent the interbedded igneous rock of Bittadon, which occurs a little below the level of the Mortehoe slates; the red grits of South Devon answer to the red sandstones at the base of the Mortehoe series; while the glossy variegated slates find their representatives in the upper Mortehoe slates, which are remarkable for their glossiness.

To all appearance there is a general correspondence in the stratigraphical succession, and not a little similarity in the lithological characters of the strata. If the view here adopted is correct, all the rocks of South Devon correspond to a large proportion of those of North Devon which Mr. Etheridge has grouped under the term Middle Devonian. The lower part of the Hangman grits appears to be absent, but it seems probable that very little of the Mortehoe slates are wanting. This view is, however, not that which is generally accepted. Thus the lower gritty slates of Looe and Meadfoot are ranked as Lower Devonian by Mr. Etheridge; while the Petherwin limestones are considered to be Upper Devonian by Mr. Salter. As to the palæontological evidence confirmatory of the Middle Devonian age of these beds, we must refer to Dr. Holl's paper for details. Here we can only state that this paper contains a list of 42 Looe (or Lower Devonian) fossils. Of these 5 are unknown elsewhere. Of the remaining 37 species, all but two, viz., *Orthis hipparionyx* and *Pterinea spinosa*, are recorded from Middle Devonian rocks elsewhere; while only 8 are known in the Lynton beds or Lower Devonian of North Devon. The balance then is in favour of their Middle Devonian age. It is also shown that the great majority of the Petherwin species are Middle Devonian fossils, while only 3 out of 72 are not known in the Middle Devonian rocks of other areas.

Before turning our notice to the Devonian strata of America, we would say a few words about the Brachiopodous fauna of Great Britain. In the elaborate tables contained in the anniversary addresses of Professor Ramsay to the Geological Society of London, a few years ago, numerical estimates are given of the species occurring in the various primary and secondary formations of Great Britain. The figures relating to the brachiopoda are as follows :—

	Genera.	Species.
Lower Silurian	15	100
Upper Silurian	16	91
Devonian	14	96
Carboniferous	16	123
Permian	10	23
Lias	9	39
Oolites	7	69
Cretaceous	14	59
Tertiary	6	9
Recent	6	7

From this table alone it would seem that the maximum development of the class was in the carboniferous period, but it would not be safe to infer that the brachiopoda as a class were more predominant in this period than any other. On analysing the tables given by Professor Ramsay, it may be concluded that the brachiopods were the predominant molluscan type throughout the Silurian and Devonian periods, when they specifically far outnumber any other class. During the carboniferous period all the classes of mollusca are well represented, but the brachiopoda have yielded fewer species than any other class, and in no subsequent period do they regain the same important place as in the pre-carboniferous strata. The fluctuations in absolute numbers no doubt depends largely upon the thickness and nature of the beds, which differ for each formation, and the relative number of each class found may also depend on the same causes, but in a far less degree. Allowing for these disturbing elements it seems unquestionable that brachiopods held the first rank in the earliest ages, and gradually dwindled into a decided minority in the later geological epochs. The point which we wish to indicate more particularly now, is the marked contrast in the development of the brachiopoda relatively to other mollusca in the Devonian and in the carboniferous periods. This is shown in the subjoined table in which the number of brachiopoda known from each group is assumed to be 100, and the relative numbers of the other classes is calculated on this basis :—

	Lamelli-branchiata.	Gastero-poda.	Cephalo-poda.
	sp.	sp.	sp.
Lower Silurian	41	20	37
Upper Silurian	82	40	50
Devonian	50	48	50
Carboniferous	235	150	110
Permian	141	96	9
Lias	330	90	310
Oolite	860	530	200
Cretaceous	580	200	300

In many cases the Devonian or carboniferous age of a set of fossils from a given series of British beds, may be settled by ascertaining what proportion the brachiopoda form relatively to the other classes.

There are 23 genera and sub-genera of brachiopoda recorded from British Silurian rocks, and 12 of them, or rather more than 50 per cent. also occur in Devonian strata, where they are joined by 12 other genera. Of the 24 Devonian genera, 15, or 62 per cent., ascend into the carboniferous beds, so that the connection is somewhat closer with the carboniferous than with the Silurian period. The forms which first appear in the British Devonian are *Camarophoria, Cyrtina, Davidsonia, Merista, Productus, Rensselæria, Spiriferina, Streptorhynchus, Stringocephalus, Strophalosia, Terebratula, Uncites* [Brachiopoda, E. C. S. col. 189].

The Devonian strata of America are so widely different from those of Europe, that no stratigraphical conformity can be detected between them. In America there is another important difference, which is, that the Devonian rocks are underlain by Silurian, and overlain by carboniferous formations; and the connection with the Silurian beds is such that there is some dispute as to what strata shall be regarded as the base of the Devonian group. The strata were first worked out minutely by the geological surveyors of the state of New York, and their arrangement and nomenclature is usually taken as a standard for comparison by the geological surveyors of other states. This arrangement is in the main that followed by Dana in his 'Manual of Geology,' who tabulates the strata thus :—

5. Catskill period.	Catskill red sandstone.
4. Chemung period.	2. Chemung group.
	1. Portage group.
3. Hamilton period.	3. Genesee beds.
	2. Hamilton group.
	1. Marcellus group.
2. Corniferous period.	3. Upper Helderberg group.
	2. Schoharie grit.
	1. Caudagalli grit.
1. Oriskany period.	Oriskany sandstone.

The deposits have undergone far less stratigraphical disturbance and obscuration than those of Europe, and can be followed over immense areas of ground. As a general rule the coarse-grained, shallow water deposits attain their greatest thickness along the Appalachians, and thin out westwardly towards the flat regions of the Mississippi and Missouri basins, where the representative deposits are mostly limestones. In the Appalachian range the greatest thickness is upwards of 15,000 feet, but in the west it does not exceed 500 feet.

The Oriskany sandstone is several hundred feet thick in the Appalachian region; about 30 feet thick in Oneida county, New York, to the west of which it rapidly thins out. It is in places a pure siliceous sand of a yellow or bluish tint, which readily crumbles down so as to be suitable for making glass. In other localities it is largely mixed with argillaceous matter, is of a dark brown or reddish colour, and abounds in nodules of hornstone. The *Caudagalli* grit is a brownish argillaceous sandstone, with a thickness of about 50 or 60 feet. Above it is the Schoharie grit, which is a fine-grained sandstone containing more or less calcareous matter. It passes up into the limestones of the upper Helderberg group, which attain in places a thickness of 350 feet, and extend over a far larger area than either of the previously mentioned groups. They are less developed in Pennsylvania than in the Michigan peninsula. They are to a certain extent the correlates of the Middle Devonian limestones of Europe, since, like them, they are coral reefs, and like them they represent that part of the Devonian period when limestones were in most active deposition in America; and like them they are the lowest Devonian limestones of their district. The Marcellus group consists chiefly of a soft, argillaceous, bituminous shale, containing a few nodular bands of limestone. The Hamilton beds are also shales and flags, with a few thin limestone beds in the west, and a few sandstone beds in the east. The Genesee group consists of a black carbonaceous shale. The greatest thickness of the beds of the Hamilton period is 1200 feet. The Portage group consists of shale and shaly sandstones, the latter prevailing in the east and the former in the west; near Lake Erie they are 6400 feet thick. The Chemung group comprises alternations of sandstones and shales, the thickness ranging from 3000 feet in the Appalachian region to 1500 feet, and less farther west. The Catskill group consists of variegated shales and sandstones, red being the prevalent colour. The upper beds are somewhat conglomeratic. Its thickness in the Appalachian is from 5000 to 6000 feet. The contrast between the Appalachian region and the district farther west is manifest from these details; but perhaps a better idea may be formed by a perusal of the following general sections in various regions as given by Dana :—

Pennsylvania.
Oriskany Period. Calcareous shales and calcareous and argillaceous sandstone, 520 feet.
Corniferous Period. Silico-calcareous shale, 200 to 300 feet; and a massive blue limestone, 80 feet.
Hamilton Period. Black and ash-coloured slate, with some argillaceous limestone, 800 feet; argillaceous and calcareous shales and sandstone, 1100 feet; upper black calcareous slate, 700 feet.
Chemung Period. Dark grey, flaggy sandstones, with some blue shale, 1700 feet; grey, red and olive shales, with grey and red sandstones, 3200 feet.
Catskill Period. Red sandstone and shale with some conglomerate, 6000 feet.
Michigan.
Oriskany Period. Cherty, sometimes agatiferous, conglomerate, 3 feet.
Corniferous Period. Brecciated limestone, 250 feet; overlaid by oolitic, arenaceous and bituminous limestones, 104 feet.
Hamilton Period. Black bituminous limestone, 15 feet; argillaceous limestones, 17 feet; crystalline limestone, with included lenticular clayey masses, 23 feet; black bituminous shale, 20 feet.
Chemung Period. Shales with intercalated flagstones and limestones, 190 feet.
Iowa.
Corniferous Period. Grey compact limestone, with some concretionary and shaly layers, 50 feet or more.
Hamilton Period. Magnesian limestones, 100 feet.
Chemung Period. Siliceous shales, sometimes calcareous, 100 feet or more.
Illinois.
Oriskany Period. Quartzose sandstone, becoming locally calcareous, 50 feet.
Hamilton Period. Coralline limestone and shale, dark-coloured fetid limestone, 120 feet; black bituminous shales and slates, 40 feet.
Missouri.
Oriskany Period. Light grey, nearly pure limestone.
Corniferous Period. Grey compact earthy limestone, with chert and some sandstone; in some parts a hard white oolite, 75 feet.
Hamilton Period. Blue argillaceous shales, with thin layers of concretionary limestone, 50 feet; black slate, 6 feet.
Tennessee.
Hamilton Period (?). A brownish black slate, often pyritiferous and bituminous, 100 feet or more.

The following general remarks which are also taken from the same authority afford an excellent resumé of the prominent geographical and palæontological features of the Devonian era. Land plants may have existed in the Silurian period, but it is only in the Devonian that we can trace any great addition to the dry land of the Azoic area, which now forms part of the American continent. But even during the Devonian period the area of North America was in the main occupied by a great sea partially surrounded by large islands. In place of the Rocky Mountains and Appalachians there were only islands, reefs, and shallow waters to mark the future site; for carboniferous strata and others of later age cover the slopes of the western mountains even over their summit plains, and a limestone of carboniferous age has been observed in one place at a height of 13,000 feet above the sea. The fossils of these rocks are the remains of animals that lived in the continental seas of that region in the next age after the Devonian. The Appalachians also contain in their structure rocks of the Devonian and carboniferous era. The Green Mountains were already in part dry land; but as rocks of the Devonian and carboniferous series constitute portions of New England they could not have had their present elevation, and were probably low. It follows, from the limited area of the land and the absence of high mountains, that there were no large rivers at the time. None of the strata bear evident marks of fresh water origin. The shale deposits and sand rocks are such as might have been formed by fresh waters; but they all contain fossils, few or many, which are of the same genera, and often the same species with those of beds obviously marine. Proofs of fresh water depositions, therefore, still fail us. Their absence may be accounted for on the grounds that there were no great rivers, and that the material borne to the area would be worked up by the waves, while such land deposits as existed would be re-arranged during periods of submergence. The history of the Devonian period is a history of successive oscillations in the continental level, the position of the accumulating deposits varying more to the east or to the west with the varying location of the subsiding or emerging areas. Throughout the whole, the Appalachian region continued to be well defined. Its deposits consisted mainly of shales and sandstones, and they have a total thickness of at least 15,000 feet; while in the west the rocks are for the most part limestones, with a thickness of less than 500 feet. It appears, moreover, that in the Devonian as well as Silurian age the interior region was covered with but thin beds of any kind, thin sandstones where sandstones were formed, and thin limestones, that is, thin as compared with the contemporaneous shales and sandstone strata farther east; and hence the oscillations of level there indicated are small as compared with those of the Appalachian region. Moreover, from the prevalence of limestone strata in the west, we learn that the great Mediterranean sea of the Silurian age was continued far into the Devonian, opening south into the Atlantic and Gulf of Mexico, and reaching north probably to the Arctic. Through some parts of the west, the Niagara and Upper Helderberg limestones, the formations of that interior sea follow each other with but little interruption.

The introduction of land plants and that of fishes are the two great steps of progress that especially mark the Devonian age. The land plants belong to two prominent groups—Conifers and Acrogens. The former are the lowest of flowering plants, the latter the highest of the flowerless plants, or cryptogams. Mosses, an inferior group of cryptogams, are unrepresented. Thus the new creations commenced with neither the highest nor the lowest of plants, but at an intermediate point, where the lower and higher series came together. There was neither moss nor grass; and no showy flowers to be contrasted with the verdure. The conifers have unconspicuous flowers, and of all flowering plants approximate most nearly in fructification to the acrogens. Moreover, between the acrogens and the conifers of this era, there was an intermediate group (although most closely related to the latter), which included the *Sigillariæ*, so that there was a remarkable unity in the early botany of the world. The acrogens belonged to the *Lycopodium, Equisetum*, and Fern tribes. The fishes consisted of two groups, the Selachians and Ganoids; the former, be it noticed, is the highest amongst the fishes of the present seas. Many of them, but more especially Ganoids, have characters which were afterwards highly developed in the reptiles. "The progress of life during the Devonian is further seen in (*a*) the introduction of many new genera under old tribes; for example, *Productus* among brachiopods, which began in America in the corniferous period, and had its maximum display and also its extinction in the carboniferous age; *Goniatites*, among cephalopods, which had its earliest American species in the Hamilton period, and became extinct at the same time with *Productus*,—a genus of interest, as it is the first of a family (that of Ammonites) which had a wonderful extension under other genera in the Reptilian age, and became extinct to its very last species at the close of that age; *Nucleocrinus*, the earliest (after a single Silurian genus) of the *Pentremites*, another of the eminently carboniferous types; the ellipsoidal form of *Nucleocrinus* is changed to the pentagonal of *Pentremites* with the first of the subcarboniferous species, or even before, in the Upper Devonian. (*b*) The complete or approximate extinction of tribes, as that of the Cystids, which ended with the Oriskany period in America, and the epoch of the Eifel limestone in Europe; that of *Favistella, Heliolites*, and other genera of corals and crinoids; that of *Atrypa, Calceola, Stringocephalus*, and other genera of brachiopods; that of the chain coral, or *Halysites*, which does not appear above the upper Silurian in America, but is found in the Eifel limestone in Europe; that of trilobites, which, after there had been, under a succession of genera, over 600 species, came nearly to its end in the Devonian, the old genera being all extinct, and only three new ones appearing in the carboniferous to close off this prominent palæozoic type; the *Orthoceras* family, species of which are comparatively rare fossils after the Devonian age. (*c*) In the historical changes in tribes or genera: for example, the *Spirifers*, which began in narrow species in the Upper Silurian, became broad-winged and very numerous in the Devonian, and continued thus into the carboniferous; the genus *Productus*, whose earliest species are very small and few, are afterwards of large size and numerous. These changes do not consist in the gradual variation of the earlier species; for species are essentially constant in their characteristics. They become apparent solely in the succession of species, the later species created differing in the particulars mentioned from those which preceded them."

Many of the beds or groups noticed by the surveyors of New York extend into Canada, and have been described by Sir William Logan and his staff. The Oriskany sandstone varies from six to twenty-five feet in thickness, and is chiefly composed of grains of quartz which are in some places very minute and cemented with a compact white quartzite, and in others the grains are coarse, well rounded, and associated with calcareous and felspathic matter. In the lower beds there is frequently found a large quantity of chert or limestone, which not unfrequently fills up fissures in the underlying limestone. It abounds in organic remains, the principal species being *Favosites gothlandica, F. hemisphærica, F. turbinata, Zaphrentis prolifica, Heliophyllum exiguum, Cystiphyllum sulcatum, Strophomena rhomboidalis, S. inequistriata, S. perplana, S. magnifica, S. magniventra, S. ampla, Chonetes hemispherica, Orthis musculosa, Centronella glansfaga, Stricklandia elongata, Rensselæria ovalis, R. ovoides, Pentamerus aratus, Spirifera arenosa, S. arrecta, Cyrtia rostrata, Atrypa reticularis, Conocardium trigonale, Avicula arenosa, Platyostoma ventricosa, Platyceras nodosum, Calymene Blumenbachii, Phillipsii crassimarginata, Dalmanites anchiops*, and an undetermined species of fish.

The *Cauda galli* and Schoharie grits have not been detected in Canada, and the next overlying bed is the limestone of the upper Helderberg group. It forms a large portion of the surface of Western Canada, being exposed over an area of between 6000 and 7000 square miles, and the thickness is estimated at about 160 feet. It contains an abundance of chert, which occurs in bands of nodules, or in solid beds from one to four inches in thickness, and resembles the bands of flints in chalk. The chert also resembles the flint in containing organic remains of a similar nature, such as sponge spicules, diatoms, desmids, and bodies which closely resemble *Xanthidia*. The corniferous limestone differs from those of Silurian age beneath in being remarkably free from carbonate of magnesia; but it is interstratified in places with thin bands of yellowish dolomite. All the beds are more or less bituminous, the petroleum being frequently found in the hollow cavities of the corals and other fossils. Its distribution is, however, peculiar, since some beds, more especially such as are crowded with *Heliophyllum*, are saturated with the oil, while others contain very little. The species occurring in this group are:—

Fistulipora Canadensis.
Favosites gothlandica.
F. hemispherica.
F. basaltica.
F. turbinata.
F. cervicornis.
F. polymorpha.
Michelinia convexa.
M. intermittens.
M. favosidea.
Syringopora Maclurei.
S. Hisingeri.
S. perelegans.
Zaphrentis prolifica.
Z. gigantea.
Z. exiguum.
Heliophyllum eriense.
H. canadense.
H. colligatum.
Phillipsastrea gigas.
Clisiophyllum oneidaense.
Blothrophyllum decorticatum.
Eridophyllum verneuilianum.
E. Simcoense.
Diphyphyllum arundinaceum.
D. stramineum.
Cystiphyllum sulcatum.
C. senecaense.
C. grandis.
Orthis livia.
O. iowensis.
Streptorhynchus pandora.
Strophomena rhomboidalis.
S. ampla.
S. Pattersoni.
S. inæquiradiata.
S. demissa.
Chonetes arcuata.
Rhynchonella thalia.
R. tethys.
Pentamerus aratus.
Stricklandia elongata.
Centronella glansfaga.
C. hecate.
Leptocœlia flabellites.
L. concava.
Spirifera duodenaria.
S. fimbriata.
S. raricosta.
S. bimesialis.
Cyrtina rostrata.
Athyris clava.
A. clusia.
A. maia.
Spirigera concentrica.
Atrypa reticularis.
Lucina elliptica.
Conocardium trigonale.
Vanuxemia Tomkinsi.

Platyostoma ventricosa.
Loxonema cotterana.
Euomphalus deceivi.
Avicula decussata.
Orthoceras sp.
Cyrtoceras sp.
Phacops bufo.
Phillipsia crassimarginata.
Dalmanites sp.
Fish remains.

The Marcellus group does not appear to extend to Canada. The next succeeding, or Hamilton group, does occur in Canada, and consists of alternations of grey calcareous shales and grey encrinal limestones. The principal fossils in these beds are:

Favosites gothlandica.
F. turbinata.
F. polymorpha.
F. cervicornis.
F. hemisphærica.
Alveolites Rœmeri.
A. Fischeri.
A. Goldfussi.
Trachypora elegantula.
T. irregularis.
Striatopora linnæana.
Diphyphyllum Archiaci.
Zaphrentis prolifica.
Heliophyllum Halli.
H. tenuiseptatum.
Cystiphyllum americanum.
Pentremites Rœmeri.
Strophomena ampla.
S. inequistriata.
S. convexa.
S. lepida.
Orthis Vanuxemi.
O. perversa.
Rhynchonella Laura.
Spirifera mucronata.
S. parryana.
S. sculptilis.
Cyrtia hamiltonensis.
Athyris concentrica.
Charionella rostrata.
Retzia Chloe.
Atrypa reticularis.
Lucina elliptica.
Pleurotomaria sp.
Orthoceras sp.
Phacops bufo.
Dalmanites sp.

The higher members of the Devonian series are almost wanting in Western Canada, being represented only by a moderate thickness of highly fissile, black, bituminous shales, which may correspond with the Genesee shales of the New York surveyors. But few fossils have been recorded from these shales, and most of them are plants, such as *Calamites inornatus*, *Sagenaria veltheimiana*, &c. It is highly probable, however, that these higher members are well developed at Point Gaspé in Eastern Canada. At this locality there are about 2000 feet of strata, mostly limestones, which appear to belong to the uppermost Silurians; they pass up conformably, both in a stratigraphical and palæontological sense, into a mass of strata upwards of 7000 feet thick, which is believed to represent the great portion of the Devonian series. The beds are remarkably uniform in general character from top to bottom, consisting of drab-coloured and variegated sandstones, separated by partings of variedly coloured argillo-arenaceous shales. The lowermost sandstones are apparently those of the Oriskany group, and the uppermost 1800 feet of strata are said to resemble the Catskill group. The Gaspé sandstones have yielded numerous plant remains, such as *Psilophyton princeps*, which frequently has a vertical position above a seam of clay in which its roots are buried; *Selaginites formosus*, *Cordaites angustifolia*, *Lepidodendron gaspianum*, *Prototaxites Logani*, &c.

In what are considered to be the Upper Devonian strata of New Brunswick have been discovered an extensive series of plants associated with a few insects, which are, at present, the earliest representatives of their kinds. The plants were described in vol. 18 of the 'Quarterly Journal of the Geological Society of London,' and comprise the following species:—

Dadoxylon Onangondianum. Dawson.
Sigillaria palpebra. Dawson.
Stigmaria ficoides (var.). Brongt.
Calamites transitionis. Göpp.
Calamites cannæformis. Brongt.
Asterophyllites annularis. Dawson.
A. latifolia. Dawson.
A. scutigera. Dawson.
A. longifolia. Brongt.
A. parvula. Dawson.
Annularia acuminata. Dawson.
Sphenophyllum antiquum. Dawson.
Pinnularia dispalans. Dawson.
Lepidodendron gaspianum. Dawson.
Lycopodites Matthewi. Dawson.
Psilophyton elegans. Dawson.
P. glabrum. Dawson.
Cordaites Robbi. Dawson.
C. angustifolia. Dawson.
Cyclopteris Jacksoni. Dawson.
C. obtusa. Lesquereux.
C. varia. Dawson.
C. volida. Dawson.
Neuropteris serrulata. Dawson.
N. polymorpha. Dawson.
Sphenopteris Hœninghausi. Brongt.
S. marginata. Dawson.
S. Harttii. Dawson.
S. Hitchcockiana. Dawson.
Hymenophyllites Gersdorffii. Goepp.
H. obtusilobus. Goepp.
H. curtilobus. Dawson.
Pecopteris (Alethopteris) discrepans. Dawson.
P. (A.) ingens. Dawson.
P. (A.) obscura? Lesquereux.
Trichomanites.
Cardiocarpum cornutum. Dawson.
C. obliquum. Dawson.
Trigonocarpum racemosum. Dawson.

The insects consist of half a dozen specimens, the relics of as many species, all of which are referable to the Neuropterous order. Descriptions of them are given by Mr. Scudder in vol. v. of the 'Geological Magazine, p. 172, et seq. They comprise *Gerephemera simplex*, which is said to belong to the family *Ephemerina*; *Platephemera antiqua*, which is also assigned to this family, although it has a neuration very different from any Ephemerid known; the species was very large, having an expanse of wing of about five inches. *Dyscritus vetustus*, which is represented by a fragment too small to indicate its family relations. *Lithentomum Harttii* does not belong to any existing family, but is most nearly allied to *Hemeristina*. *Homothetus fossilis* is the representative of a family intermediate between *Odonata* and *Sialina*. *Xenoneura antiquorum*, which Mr. Scudder says is the most interesting of all, represents a new family, in which the most striking peculiarity "is the development of apparently independent veinlets, forming portions of concentric rings at the base of the wings. There is nothing analogous to it among living *Neuroptera*, and I can only compare it to the stridulating organ of some male saltatorial *Orthopteron*. Is it possible that this insect was a member of a group forming a synthetic type between *Orthoptera* and *Neuroptera*?"

The annexed table given by Mr. Etheridge may be substituted for that in E. C. vol. iv. col. 80. We have inserted the letters L, M, U, and C, to indicate the occurrence of the species in the Lower, Middle, or Upper Devonian, or Carboniferous strata. The list refers only to the beds of Western Europe, and the range or position is given on Mr. Etheridge's authority:—

PLANTÆ.

Knorria dichotoma. Haught. U.
Adiantites hibernicus. Forbes. U.
Sagenaria veltheimiana. Sternb. U.
Bornia transitionis. Göpp. U.

AMORPHOZOA.

Scyphia turbinata. Goldf. M.
Steganodictyum cornubicum. M'Coy. L. M. (A fish scale.)
S. Carteri. M'Coy. L.
Sphærospongia tessellata. Phillips. M.
Stromatopora concentrica. Goldf. M.
S. placenta. Lonsd. M.
S. polymorpha. Goldf. M.
S. ramosa. Brass. M.
S. verticillata. M'Coy. M.

ACTINOZOA.

Acervularia Battersbyi. Milne-Edw. M.
A. coronata. M.-Edw. M.
A. Goldfussii De Vern. M.
A. intercellulosa. Phill. M.
A. pentagona. Goldf. M.
A. Rœmeri De Vern. M.
A. limitata. M.-Edw. M.

Alveolites Battersbyi. M.-Edw. M.
A. compressa. M.-Edw. M.
A. suborbicularis. Lam. L. M.
A. vermicularis. M'Coy. M.
Amplexus tortuosus. Phill. M. U.
Arachnophyllum Hennahii. Lonsd. M.
Battersbyia inequalis. M.-Edw. M
Campophyllum flexuosum. Goldf. M.
Chonophyllum perfoliatum. Goldf. M.
Cyathophyllum æquiseptum. M.-Edw. M.
C. boloniense. Blainv. M.
C. cæspitosum. Goldf. M. U.
C. ceratites. Goldf. M.
C. damnoniense. Lonsd. M.
C. helianthoides. Goldf. M.
C. hexagonum. Goldf. M.
C. Marmini. M.-Edw. M.
C. obtortum. M.-Edw. M.
C. Rœmeri. M.-Edw. M.
C. Sedgwickii. M.-Edw. M.
Cystiphyllum damnoniense. Lonsd. M.
C. vesiculosum. Goldf. M.
Emmonsia hemisphærica. M.-Edw. M.
Endophyllum abditum. M.-Edw. M.
E. Bowerbankii. M.-Edw. M.
Favosites Goldfussii. D'Orb. M.
F. cervicornis. Blainv. L. M.
F. dubia. Blainv. M.
F. fibrosa? Goldf. L. M.
F. reticulata. Blainv. M.
Fistulipora cribrosa. Goldf. M. U.
Hallia Pengellyi. M.-Edw. M.
Heliolites porosa. Goldf. M.
Heliophyllum Hallii. M.-Edw. M.
Metriophyllum Battersbyi. M.-Edw. M.
Michelinia antiqua. M'Coy. U. C.
Pachyphyllum devoniense. M.-Edw. M.
Petraia bina? Lonsd.
P. celtica? Lonsd. L. M. U.
P. gigas. M'Coy. M.
P. pleuriradialis. Phill. L. U. C.?
Pleurodictyum problematicum. Goldf. L. M. U.
Smithia Pengellia. M.-Edw. M.
S. Bowerbankia. M.-Edw. M.
S. Hennahii. Lonsd. M.
Spongiophyllum Sedgwickii. M.-Edw. M.
Strephodes gracilis. M'Coy. M.
Syringophyllum cantabricum. De Vern. M.

Echinodermata.

Actinocrinus tenuistriatus. Phill. L. M. U.
A. triacontadactylus? Mill. L. M. U. C.
Adelocrinus hystrix. Phill. U. C.
Cupressocrinus crassus. Phill. M.
Cyathocrinus distans. U.
C. ellipticus. U. C.
C. macrodactylus. M. U.
C. megastylus. L.
C. nodulosus. M.
C. pinnatus. Goldf. L. M. U. C.
C. geometricus. Goldf. M. C.
C. variabilis. Phill. M. U. C.
Hexacrinus depressus. Aust. M.
H. interscapularis. Phill. M.
H. macrotatus. Aust. M.
Pentremites ovalis. Goldf. U. C.?
Platycrinus tuberculatus. Miller. M. C.
P. pentangularis. Miller. M.
Toxocrinus macrodactylus. Phill. U.
Protaster sp. M.
Palæaster sp. M.

Annelida.

Tentaculites annulatus. Schloth. M.
T. scalaris. Schloth. L. M.

Crustacea.

Bronteus flabellifer. Goldf. M.
Cheirurus articulatus. Münst. M.
C. Sternbergii. Münst. M.
Cypridina serrato-striata. Sand. M. U.
Harpes macrocephalus. Goldf. M.
Homalonotus Herschellii? Phill. L. M.
H. armatus. L. M.
Phacops granulatus. Münst. M. U.
P. laciniatus. Roem. L. M. U.
P. latifrons. Bronn. L. M. U.
P. punctatus. Stein. M.
P. lævis. Münst. M. U.
P. cryptophthalmus. M.

Polyzoa.

Berenicea M'Coyii. M.
Ceriopora similis. Phill. M. U.? C.
C. gracilis. Phill. U.
Fenestella antiqua. Gold. L. M. U. C.

Fenestella arthritica. Phill. M.
F. plebeia. M'Coy. U. C.
F. prisca. Goldf. M. C.
Glauconome bipinnata. Phill. U. C.
G. sp. M.
Hemitrypa oculata. Phill. L. M.
Polypora laxa. Phill. M. U. C.
Ptylopora flustriformis. Phill. M.
Retepora repisteria. Goldf. L. M.

Brachiopoda.

Athyris bartonensis. Dav. M.
A. concentrica. V. Buch. L. M. U.
A. decussata. Sow. M.
A. indentata. Sow. M. U.
A. lachryma. Sow.? M. U.
A. newtonensis. Dav. M.
A. oblonga. Sow. U. C.
A. phalæna. Phill. M.
Atrypa desquamata. Sow. L. M. U.
A. flabellata. Goldf. M.
A. lens. Phill. M.
A. lepida. Goldf. L. M.
A. reticularis. Linn. L. M. U.
A. r. var. aspera. Schloth. L. M. U.
Calceola sandalina. Linn. M. [This belongs to the *Actinozoa*.]
Camarophoria rhomboidea. Phill. M.
Chonetes hardrensis. Phill. L. M. U. C.
C. minuta. Goldf. M.
Cyrtina amblygona. Phill. M.
C. demarlii. V. Buch. M.
C. heteroclyta. Defr. L. M. U.
C. multiplicata. Dav. M.
Davidsonia Verneuilii. V. Buch. M.
Discina nitida. Phill. U. C.
Leptaena interstrialis. Phill. M.
L. laticosta. Conrad. L. M.
L. nobilis. M'Coy. L. M.
Lingula squamiformis. Phill. U. C.
Merista plebeia. Sow. M.
Orthis arcuata. Phill. L. M.
O. granulosa. Phill. L. M.
O. hians. V. Buch.
O. hipparionyx. Vanux. L.
O. interlineata. Sow. M. U.
O. striatula. Schloth. M. U.
Pentamerus biplicatus Schnurr. M.
P. brevirostris. Phill. M.
Productus longispinus. Dav. U.?
P. prælongus. Sow. U.
P. subaculeatus. Murch. M. U.
P. scabriculus. Mait. U. C.
Rensselæria stringiceps. Roem. L. M.
Rhynchonella acuminata. Mart. M.
R. angularis. Phill. M.
R. bifora. Phill. M.
R. cuboides. Sow. L. M.
R. laticosta. Phill. M. U.
R. lumatoniensis. Dav. M.
R. ogwelliensis. Dav. M.
R. pengelliana. Dav. L.
R. pleurodon. Phill. M. U. C.
R. primipilaris. V. Buch. M.
R. protracta. Sow. M.
R. pugnus. Mart. M. U. C.
R. reniformis. Sow. M. U. C.
R. sphærica? Sow. M.
R. triloba. Sow. M.
R. implexa? V. Buch. M.
Retzia ferrita. V. Buch. M.
Spirifera canalifera. Valen. L. M.
S. comprimata? Schloth. M. U.
S. curvata. Schloth. L. M.
S. cultrijugata. Roem. M. U.
S. disjuncta. Sow. M. U.
S. hysterica. Schloth. L. M. U.
S. lævicosta. Valen. L. M. U.
S. lineata. Mart. M. U.
S. macronata. Hall.
S. megaloba. Phill. U.
S. mesomala. Phill. U.
S. newtonensis. Dav. M.
S. obliterata. Phill. U.
S. nuda. Sow. M.
S. rudis. Phill. U.
S. simplex. Phill. M.
S. speciosa. Schloth. L. M.
S. Urii. Fleming. M. U. C.
S. subcuspidata. Schnurr. M.
S. undifera. Roem. M.
S. u. var. undulata. Roem. M.
Spiriferina cristata. Schloth. L. M. U. C.
S. insculpta. Phill. M. C.
Stringocephalus Burtini. Defr. M.
Streptorhynchus crenistria. Phill. M. U. C.
S. gigas. M'Coy. L.

Streptorhynchus persarmentosus. M'Coy. L.
S. plicata. Sow. U.
S. semicircularis. Phill. U.
S. umbraculum. Schloth. L. M.
Strophalosia productoides. Murch. U.
Strophomena rhomboidalis. Wahl. M. U.
Terebratula elongata ? Schloth. M. U.
T. sacculus. Mart. M. U.
T. juvenis. Sow. M.
T. newtonensis. Dav. M.
Uncites gryphus. Schloth. M.

Lamellibranchiata (*Monomyaria*).

Avicula exarata. Phill. M.
A. subradiata. Phill. M. U.
Aviculopecten alternatus. Phill. U.
A. arachnoideus. Phill. U.
A. granosus. Sow. U.
A. granulosus. Phill. U.
A. nexilis. Sow. U.
A. pectinoides. Sow. U.
A. plicatus. Sow. M. C.
A. polytrichus. Phill. L. U.
A. rugosus. Phill. M.
A transversus. Sow. M. U.
Pterinea anisota. Phill. M. U.
P. cancellata. Phill. U.
P. radiata. Goldf. M.
P. reticulata. Phill. M. U.
P. rudis. Phill. U.
P. spinosa. Phill. L. U.
P. texturata. Phill. M.
P. ventricosa. Goldf. L. U.
P. subradiata. Sow. M.

Lamellibranchiata (*Dimyaria*).

Cardiola retrostriata. Keys. U.
Clidophorus ovatus. Sow. M. U.
Conocardium aliforme. Sow. M. U. C.
C. minax. Phill. M.
Corbula Hennahii. Sow. M.
Cucullæa amygdalina. Phill. M. U. C.
C. angusta. Sow. U.
C. complanata. Phill. U.
C. depressa. Phill. U.
C. Hardingii var. Sow. U.
C. trapezium. Sow. U.
C. unilateralis. Sow. U.
Ctenodonta elliptica. Phill. ? U.
C. Krachtæ. Roem. L. M.
C. latissima. Phill. U.
C. lineata. Phill. M. U.
C. plicata. Phill. U.
C. pullastriformis. M'Coy. U.
C. antiqua. U.
Curtonotus unio. Salt. U.
C. elegans. Salt. U. C.
Cypricardia Phillipsii ? D'Orb. U.
Leptodomus constrictus. M'Coy. U.
Megalodon carinatus. Gold. M.
M. cucullatus. Sow. L. M.
Modiola amygdalina. Phill. U.
M. scalaris. Phill. M.
Mytilus damnoniensis. Phill. M.
Orthonota semisulcata. U.
Sanguinolaria elliptica. Phill. U.
S. sulcata. Münst. M. U.
Sanguinolites complanatus. Phill. U.
S. liratus. Phill. U.
Schizodus deltoideus. Phill. M. U.
Myalina sp. M.

Gasteropoda.

Acroculia sigmoidalis. Phill. M.
A. vetusta. Sow. M. U. C.
A. triloba Phill. M.
Euomphalus annulatus. Phill. M.
E. circularis. Phill. M.
E. radiatus. Phill. M.
E. serpens. Phill. M. U.
E. lævis. Goldf. M.
E. planorbis. Vern. M. C.
Helminthodon sp. M.
Loxonema hennahiana. Phill. M.
L. lincta. Phill. M.
L. nexilis. Phill. M.
L. præterita. Phill. M.
L. reticulata. Phill. M.
L. rugifera. Phill. M. U. C.
L. sinuosa. Phill. U.
L. tumida. Phill. M. U. C.
Macrocheilus brevis. Sow. M.
M. elongatus. Phill. M.
M. harpula. Sow. M.
M. imbricatus. Sow. M.
M. neglectus. Phill. U.

Macrocheilus subcostatus. Schloth. M.
M. ventricosus. Goldf. M.
Murchisonia angulata. Phill. M. U. C.
M. bigranulosa. D'Arch. M. U.
M. geminata. Phill. M. U.
M. spinosa. Phill. M. C.
M. tricincta. Phill. M.
Natica meridionalis. Phill. M. U.
N. nexicosta. Phill. U.
Nerita deformis. Sow. M.
Pleurotomaria aspera. Sow. L. M. U.
P. cancellata. Phill. U.
P. cirriformis. Sow. M.
P. expansa. Phill. U. C.
P. gracilis. Phill. U.
P. impendens. Sow. M.
P. monolifera. Phill. M. U. C.
P. multispira. M.
Scoliostoma textata. Phill. M.
Trochus Boueii. Stein. M.
Turbo cirriformis. Sow. M.
Vermetus antitorquatus. Phill. M. U.
V. annulosus. M.

Nucleobranchiata.

Bellerophon bisculcatus. Roem. L. M. U.
B. striatus. Bronn. L. M.
B. subglobatus. M'Coy. U.
B. Urii. Fleming. U. C.
B. hiulcus. Sow. U. C.
Porcellia Woodwardii. Sow. L. M. U.
P. striata. L. M.
P. Symmondsii. U.

Pteropoda.

Conularia sp. M.

Cephalopoda.

Clymenia bisulcata. Münst. U.
C. fasciata. Phill. U.
C. lævigata. Münst. M. U.
C. Munsteri. M'Coy. U.
C. Pattisonii. M'Coy. U.
C. pleurisepta. Phill. U.
C. quadrifera. M'Coy. U.
C. sagittalis. Phill. U.
C. striata. Münst. M. U.
C. valida. Phill. U.
C. undulata. Münst. U.
Cyrtoceras armatum. Phill. M.
C. bdellalites. Phill. L. M.
C. fimbriatum. Phill. M.
C. marginale. Phill. M.
C. nautiloideus. Phill. M.
C. nodosum. Phill. M.
C. obliquatum. Phill. M.
C. ornatum. Goldf. M.
C. quindecimale. Phill. M.
C. reticulatum. Phill. M.
C. rusticum. Phill. M.
C. subornatum. M'Coy. M.
C. tridecimale. Phill. M.
Goniatites biforus. Phill. M. U.
G. excavatus. Phill. M. C.
G. globosus. Munst. M.
G. linearis. Munst. M.
G. serpentinus. Phill. M. C.
G. spirorbis ? Phill. U. C.
G. subsulcatus. Bronn. U.
G. transitionis. Phill. M.
G. vinctus. Sow. U.
G. compressus ? M.
Nautilus germanus. Phill. M.
N. ? megasipho. Phill. U.
Orthoceras cinctum. Sow. M. U. C.
O. cylindraceum. Sow. M. ? U. C.
O. cylindricum. Sow. M. U.
O. ellipsoideum. Phill. M.
O. ibex. Sow. M. U. ?
O. imbricatum ? Wahl. U.
O. lineolatum. Phill. U. C.
O. ludense ? M. U.
O. Phillipsii. D'Orb. U.
O. striatulum. Sow. U.
O. tentaculare. Phill. M. U.
O. tubicinella. Sow. M.
O. undulatum. Sow. M. U. C.
O. gracile. L. M.
O. striatum. Sow. U. C.
Poterioceras fusiforme. Sow. M. C.

Pisces.

Phyllolepis concentricus. Ag. L.
Holoptychius. L. U.
Ichthyodorulite. L.
Fish remains. M.

DIAMOND [E. C. vol. ii. cols. 323, 324]. Under CARBON, E. C. S., attention is drawn to the remarkable differences of property met with in the various forms of native carbon, of which the diamond is at once the rarest and most beautiful; and it is there shown that in many cases there is a correlation between the intensity of a property and the density of the carbon. The object in that article was to trace out the resemblances hidden under the guise of variety of condition; but in this article attention will be given rather to the differential points.

Few substances can compare with carbon in being jet black and opaque in one condition, and colourless or tinted and transparent in another. It seems difficult to conceive that graphite could be rendered transparent simply by pressing its particles closer together, and yet it is known that when the diamond is subjected to intense heat, *i.e.*, to intense repulsive force, its particles are spaced out more, and it becomes as black and opaque as graphite. As no chemical change is effected, there seems reason to believe that if the same amount of repulsive force was applied as pressure, graphite might be rendered transparent. This phenomenon is indeed very similar to what is met with in water. In the light flocculent form of snow it is an opaque white; but when rendered compact it is colourless, transparent, and denser. In this case transparency is superinduced by pressure, as in the formation of glacial ice. However probable this view may be, experiments are still wanted to show that increase of density will alone suffice to convert graphite into diamond. The former, in the amorphous state, is softer than the finger nail, while the latter is the hardest known substance; the former will conduct electricity almost as well as some metals, while the latter is a bad conductor; the one crystallises in the monometric system, but the other occurs in crystals belonging to the hexagonal system. There even appears to be a marked chemical distinction, for although all the forms of carbon will combine with oxygen to form carbonic acid, which has the same properties in all cases, yet, according to Brodie, graphite is peculiar in its behaviour towards certain oxidising agents, such as a mixture of nitric and sulphuric acids, or nitric acid and chlorate of potassium. Under these circumstances it gives rise to a compound which Brodie calls graphitic acid, and represents by the formula $C_{11} H_4 O_5$ or $Gr_4 H_4 O_5$. The symbol Gr stands for *graphon*, the name assigned to this form of carbon. It is certainly remarkable that the same substance (graphite) should combine with an atomic weight of 12 under one set of circumstances and of 33 under another set, since the numbers have no simple relationship with each other. The differences in the specific heats of diamond and graphite are noticed under CARBON, E. C. S. Assuming that most of these changes are due to difference of density, there would appear to be a great analogy between carbon and sulphur.

There is no connection between the colours of the diamond and its density, and, perhaps, the latter is not always connected with the blackness of this jewel. For while on the one hand Sir D. Brewster states that the blackness is due to a multitude of minute cavities, on the other numerous observers have discovered that the black specks in some diamonds are due to foreign impurities, which are said to have a resemblance to coal; and it has been noticed that the black diamonds of Bahia are even harder than the transparent stones. These black diamonds are so hard that jewellers are unable to cleave them; but this is partly due to their being formed of interblended crystals. Little is known of the cause of the colour in diamonds. The most common tint is a brownish or yellowish, and one of the rarest, a rose colour. Some facts, brought forward by MM. Halphen in 1866, seemed to show that a molecular change might convert one into the other. Thus they had one diamond which became rose-coloured by friction, but the colour was very evanescent. They had a second of a yellow tint, which was converted into a rose-coloured one by putting it into a fire. In this case the colour lasted for 18 days, and then gradually disappeared; but it could be revived again by reheating the stone. As a phenomenon of a similar kind has long been known in the yellow topaz, it has been suggested that this diamond was not pure carbon, but a mixture or combination of that element with fluoride of aluminium. The only evidence adduced in support of this opinion is the similarity of the phenomenon in this diamond and in the topaz; but there are several difficulties which prevent its acceptance. Thus the rose colour is permanent in the topaz, but temporary in the diamond. All topazes contain fluoride of aluminium, yet it is only the yellow topaz from Brazil which is affected in the manner described; the yellow Saxon topaz loses its colour when heated, but regains it when cooled; and the topazes of other tints are not altered in colour. These facts alone would lead us to suspect that the true explanation has yet to be sought. When coloured diamonds are burnt in oxygen, they yield a yellow ash, which forms from $\frac{1}{2000}$ to $\frac{1}{500}$ of their weight. This ash gave indications of the presence of silica and iron when treated with the blowpipe. The iron is probably present as an oxide; and this, with silica, are the main ingredients of the ash of many specimens of graphite and of a few specimens of coal. In some cases the ash of the diamond has a reddish tint. In the absence of any experiments on the subject, it would be presumptuous to say that there is a connection between the colour of the diamond and of the ash, but that there is a connection between them does not seem to be a very improbable supposition; at any rate, there is apparently more to be said in favour of this hypothesis than of another recently started by De Chancourtois, that these colours are derived from petroleum. They may closely resemble the colours of products from coal tar; but there is the important difference, that the colours of the diamond are indestructible by heat, and insoluble by ether or alcohol, while those formed by the aniline compounds will withstand neither heat nor alcohol. There is sufficient similarity between the colours of carbon and those of sulphur to warrant some allusion to it; but whether the phenomena are due to similar causes is uncertain. Then we have colourless and transparent varieties, both of sulphur and carbon; the ordinary colour of the one is yellow, and of the diamond a brownish or yellowish tinge; by subjecting it to certain processes, sulphur may be rendered wine-red, while certain diamonds are rose-coloured, and both have their black modifications.

Many attempts have been made to produce diamonds by artificial means, and many attempts have also been made to ascertain how it has been formed by nature; but as yet little is known as to how the diamond may be formed, either the one way or the other. Most of the attempts to obtain it artificially have resulted in soot, not diamonds; but in a few cases microscopic crystals are said to have been formed. Thus Despretz and Lionnet have obtained crystals by the action of a current of electricity upon liquids containing carbon, such as sulphide of carbon. Despretz's diamonds were black or colourless octahedrons and plates, which entirely disappeared on the application of a moderate heat, in which respect they differ materially from native diamonds. Lionnet's gems were also crystals; but as that experimenter says nothing about their properties in the notice given by him in the 'Comptes Rendus,' vol. 63, p. 213, it is possible that his diamonds would also have been dissipated by a moderate heat. In the same volume of the work just referred to, De Chancourtois suggests that diamonds may be formed in the following way:—Submit a very slow current of carburetted hydrogen, mixed with aqueous vapour, to a very gentle oxidizing agent in a mass of sand containing traces of putrescible matter, such as starch. A process very similar to this is in operation every day near the leaky gas pipes of our streets. The carburetted hydrogen escapes slowly, and although not mixed with aqueous vapour itself, yet it may absorb such vapour from the moist earth surrounding the pipe; and this earth may contain putrescible matter, which, if it be not starch, is certainly carbonaceous. The eminent French mineralogist thinks that diamonds, or rather diamond powder, may be found in such earth. If any kind of carbon be deposited, we should expect to find, not diamonds, but a moist soot, such as is probably the colouring ingredient of the black earth found near gas pipes.

In studying the various opinions which have been given as to the mode of formation of natural diamonds, the student soon sees that the hypotheses may be classified in two groups, viz., those which advocate intense heat as the principal agent, and those which rely mostly upon water and a moderate temperature. The diamond, then, like so many other subjects in mineralogy and geology, is a bone of contention between the Neptunists and Plutonists. The one party, which we may represent by Bischof, says:—"Now, since the occurrence of the diamond speaks only in favour of the formation by aqueous agency, every hypothesis as to its igneous origin must be rejected as totally unfounded." The other party, which we would represent by Brewster, who says, after referring to the pressure cavities in diamonds:—"Such a structure is impossible in crystals formed by aqueous deposition, and hence there is not a single pressure cavity in any of them." So far as we have examined the evidence on both sides, these facts do not seem to warrant either the assertion that it is impossible for any crystal with pressure cavities to have been formed from an aqueous solution, or that every hypothesis advocating the igneous origin of the diamond is totally unfounded. We think there is something to be said on both sides, but we would forewarn the reader that our own opinion is decidedly in favour of the view that diamonds have been formed at a moderate temperature, and that water has played an essential part in the process.

Brewster's argument in favour of the igneous origin of the diamond is based mainly upon the hollows or pressure cavities found in it. Almost every diamond, when examined by polarised light and under a high magnifying power, shows minute black specks surrounded by four quadrants or sectors of polarised light. Thus the Koh-i-Noor contains three such specks, barely visible to the naked eye, while the pendants connected with it have several. Of fifty diamonds examined by Brewster nearly all contained one or more cavities of singular shapes, somewhat like insects, and invariably surrounded by luminous sectors. They are irregularly scattered through the stone, but are frequently arranged in planes, which planes, however, are said to have no relation to those of the crystal. Sir D. Brewster hence infers that a gas occupies or has occupied the cavities, and has, by its expansion, compressed the substance of the diamond so as to render it more dense in the vicinity of such cavities than in the more distant parts, and thereby capable of depolarising light. This phenomenon may be seen in almost any homogeneous substance which has been subjected to unequal pressure. For example, ordinary glass is homogeneous, and produces no effect upon polarised light; but if such glass be compressed when soft, or be unannealed, or be rendered in any way of unequal tension, it gives rise to luminous sectors similar to those seen in the diamond. In the glass the compressing force is applied to the mass as a whole, but in the diamond the compressing force has been exerted from the cavities outwards, and all its strength has been spent upon the surrounding material; but it has not been sufficient to burst the stone so as to allow of the escape of the gas. As there is no perceptible fissure in diamond, it is concluded the gas is still contained in the cavities. If so, one of four positions must be true:—1. The tension of the gas in the cavities is now sufficient to condense the diamond. 2. If not, then some cause was formerly in operation which increased the tension of the gas up to the point at which it could do so. 3. If there was no increase of tension the diamond must have been softer or more plastic than it is now. Or 4. There has been an increase both of tension in the gas and of plasticity in the diamond. The first position may be safely regarded as untenable, so that three are left to choose from. Of these the third is, we think, the most in accordance with known facts; but there is also much in favour of the fourth. These two positions may be exemplified, the one by amber, which contains cavities and luminous sectors like the diamond, and the other by the following experiment made by Sir D. Brewster. He compressed a solution of gum arabic between two plates of glass, so as to enclose a few bubbles of air. On heating the arrangement the air compressed the circumjacent gum and gave it that variation of density which produces four luminous sectors in polarised light. That the diamond was at one time softer than it is now is abundantly manifested, but how much softer is a matter for consideration. Bischof refers to a diamond in the museum of Rio de Janeiro, on whose faces are impressions of quartz grains. Goeppert refers to another in the treasury of the Emperor of Brazil, which has similar impressions; and states he has seen five others presenting the same phenomenon, one being a black diamond. The "Star of the South," before it was cut, had a deep hollow on one of its faces, in which was the impression of an octahedral crystal. The surface of the impression showed octahedral striæ, indicating that the impression was probably made by a diamond. Other faces of the same stone had hollows with impressions of striæ, such as may have been made by groups of diamonds. As isolated facts, these tell nothing as to the hardness; but they are of some importance when taken in connection with the existence of sulphide of iron in the diamond, as stated by Von Hartwig, probably of titaniferous iron, as stated by Dufresnoy, and of the pressure cavities described by Brewster. No heat that man can command has yet softened the diamond when under moderate pressure without destroying its crystalline form; and if it be supposed that it might be softened when under great pressure by the same heat, we should expect that the pressure exerted by the gas in its cavities would have spread its effects over much larger spaces than appears to be the case. The presence of the quartz grains seems to indicate that the temperature at which the diamond crystallised was below that at which quartz may remain solid. Under ordinary atmospheric pressures quartz is known to be melted, and even volatilised by a heat which has little or no effect upon the diamond; and there is no reason to believe that great pressure would render the diamond more fusible than silica. But if steam accompany the heat there is a still greater difficulty in believing that the diamond would crystallise in the presence of solid silica, seeing how readily that compound is dissolved by steam. On the whole, then, it seems more probable that the phenomena above noticed are due to the action of a gas at low tension, and of moderate temperature upon a soft substance, rather than to that of a gas at high tension and temperature upon a hard substance; and that the impressions were made upon the diamond itself by the quartz and octahedral crystals, rather than that they were formed in the diamond during the process of crystallisation.

Favre has suggested that the diamond has originated from the vapours of chloride of carbon. He notices that it is always contained in rocks of a similar nature. Thus in Brazil it occurs in a micaceous sandstone (itacolumite) when in situ, but in an angular or rolled gravel composed partly of itacolumite and partly of other rocks when not in its original place of formation; and in the Ural Mountains, the East Indies, &c., it is associated with similar rocks. But he attaches most importance to the minerals which are found in these rocks, and sometimes in close connection with the diamond. These are 39 in number, viz.:—

Iron pyrites.
Bismuthite.
Galena.
Anatase.
Hornblende.
Diallage.
The manganeses (? pyrolusite and psilomelane).
Hæmatite.
Quartz.
Garnet.
Zircon.
Ruby.
Dolomite.
Ferriferous carbonate of lime (? Brossite).
Magnetite.
Corundum.
Topaz.
Hydrophosphate of alumina and lime.
Hydrophosphate of yttria (Castelnaudite).
Silicate of yttria.
Rutile.
Kyanite.
Tourmaline.
Schorl.
Cinnabar.
Tellurium.
Copper.
Platinum.
Gold.
Marcasite.
Copper pyrites.
Cerusite.
Chromiron.
Iserine.
Pharmacosiderite.
Sphene.
Talc.
Orthoclase.
Diaspore.

Of these 32 have been produced artificially, and 30 have been obtained from their chlorides, which in the majority of cases were in the vaporous state. Commenting on this he says, "Thus of the 34 minerals [the number known to him when writing the body of his paper] 4 give no evidence either way, not having been produced artificially; 24 have been produced from volatile chlorides; 5 from chlorides in solution; and 1 from a compound not formed with chlorine. Do not these facts indicate the way in which the diamond has been formed in the earth? Notwithstanding the recent experiments by Deville, do they not show that the chloride of carbon is the combination by whose aid we ought to attempt to produce this stone?"

De Chancourtois is of opinion that diamond and graphite have been formed from carburetted hydrogen and the vapours of hydrocarbons, in the same way as sulphur is deposited from sulphuretted hydrogen. As in the latter case the hydrogen of the gas is oxidized, together with a portion of the sulphur, while the remainder is deposited in the free state; so in the former the hydrogen is oxidized, a portion of the carbon goes to the formation of carbonic acid, while the remainder crystallizes as diamond and graphite. The places where this vapour escaped and carbon was deposited he proposes to call *carbonataras*, which he supposes had more or less resemblance to the *solfataras* of the present day. If such is the way in which Nature has formed diamonds, why are they not far more abundant, seeing how numerous and wide spread are exhalations of carburetted hydrogen? In all probability these exhalations have been equally abundant in past time. Diamonds, on the other hand, are very rare, and confined to the oldest rocks of a particular character.

Nearly all the larger diamonds have been found in East India, but in 1853 a large specimen of remarkable limpidity was discovered in the Bogagem mines of Brazil. It has been named the Star of the South. It weighed originally 52·275 grammes, but in cutting it was reduced to 125 carats, so that it was somewhat heavier than the Koh-i-Noor, which weighs 103¼ carats.

Its form before cutting was that of a rhomboidal dodecahedron having a very obtuse bevelled edge on each of its faces. Its sp. gr. is 3·529 at 15° C.

In the Cyclopædia article the Koh-i-Noor is said to have been found in the mine of Colonne in 1550, and to be identical with the great Mogul diamond mentioned by Tavernier. We do not know who is the authority for the date and place of discovery; the statement is made by Dana, but is doubtless erroneous. The actual known information respecting this jewel is far less precise. According to Indian tradition the Koh-i-Noor may be traced back to the time of Bikramidtya, who flourished about 56 years before the Christian era. Disregarding tradition, however, the first distinct mention of a large diamond is by Baber, the founder of the Mogul or Tartar dynasty, who states that when his son Humaiun captured Agra in 1526 a diamond estimated to weigh 320 ratis was amongst the spoil. This stone, he says, was taken by Ala-ed-deen in 1304 during the conquest of Malwa. Tavernier saw the precious stones in the Mogul's possession, and gives a description of the largest, the weight of which he estimated at 319½ ratis = 252 carats. He also gave a figure, but as his figure and description do not correspond, there appear to be some doubts whether both refer to the same stone or not. The description, however, of the stone he saw clearly shows this was the same as that now called the Koh-i-Noor; while the figure given by him as that of the Koh-i-Noor may belong to another stone which then went by that name. Assuming then the Mogul diamond to be the same as the modern Koh-i-Noor, its history may be readily traced. For a time it remained at Delhi; it then passed into the hands of Nadir Shah, who took it with him to Khorasan; after him Shah Rokh had it; then Ahmed Shah; then Shah Soujah, who was obliged to give it up to Runjeet the Lion, as already noticed in the Cyclopædia article.

The Koh-i-Noor, by which we mean the stone so called now, appears to have been part of a larger diamond before the time of Baber. Thus Tavernier states it was originally part of a diamond weighing 787½ carats. Its weight does not seem to have been diminished from the time of Baber to that of Tavernier. The next statement we have as to its weight refers to the time when it reached England, it being then 186 carats. After it was cut by the Messrs. Garrard it weighed, as already stated, 103¼ carats. Professor Tennant is of opinion that the original form of this diamond was a rhombic dodecahedron, and that in its present state it is about a third of its original size. In his lecture on the precious stones in the Great Exhibition of 1851, delivered before the Society of Arts, March 24, 1852, he thus expresses himself on this point:—"If we give Tavernier credit as to the original weight of the stone, we may indulge in a very reasonable supposition that two other remarkable existing diamonds once formed part of it. Dr. Beke, in a paper read before the British Association at Ipswich, in 1851, says, 'At the capture of Coochan (about 1832) there was found among the jewels of the harem of Reeza Kooli Khan, the chief of that place, a large diamond slab supposed to have been cut [broken ?] from one side of the Koh-i-Noor. It weighed about 130 carats, showed the marks of cutting on the flat and largest side, and appeared to correspond in size with the Koh-i-Noor.' Another diamond which singularly corresponds with the Koh-i-Noor is the Great Russian diamond; and it is not improbable that they all formed one diamond, and that, when united, they would, allowing for the detachment of several smaller pieces in the process of cleaving, make up the weight described by Tavernier."

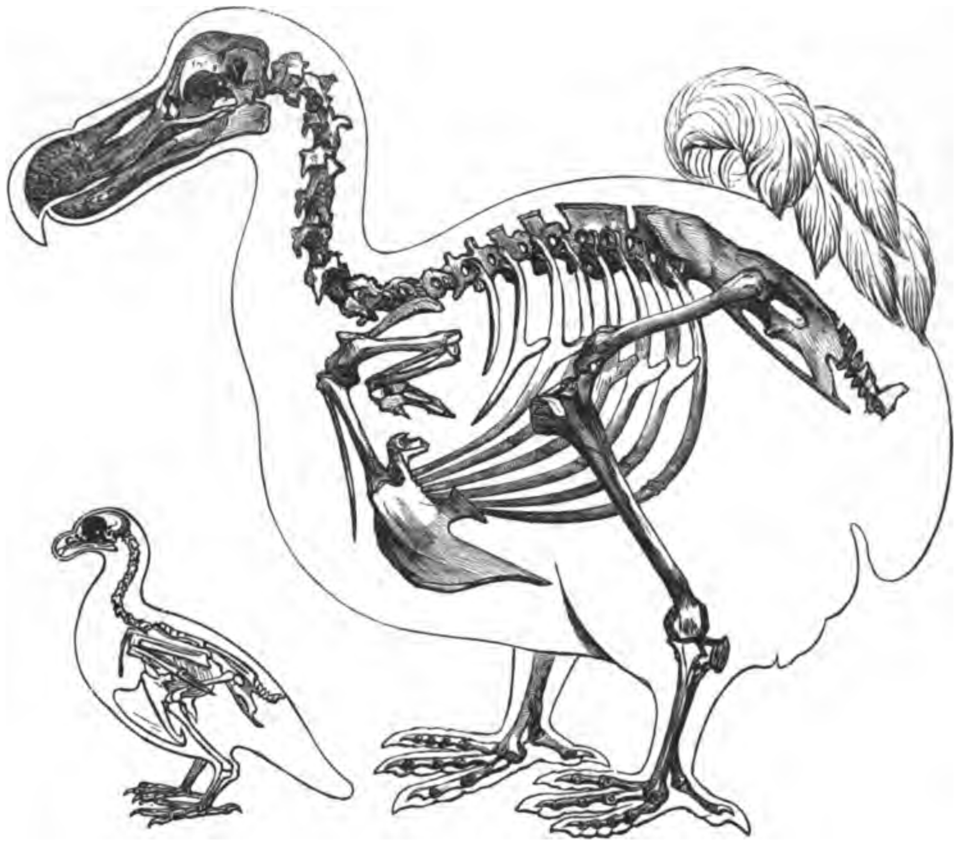
(Watts, *Dictionary of Chemistry*, arts. Carbon and Diamond; Williamson, *Chemistry for Students*, par. 61; Chancourtois, *American Journal of Science*, second series, vol. xlii. p. 271; Halphen, *Comptes Rendus*, vol. lxii. p. 1407; Geoppert, *Leonhard und Geinitz's Neues Jahrbuch für Mineralogie*, p. 198 (1864); Brewster, *Trans. Roy. Soc. Ed.* xxiii. pp. 39—44; Dufresnoy, *Comptes Rendus*, xl. p. 3; Maskelyne, *Proc. Ashmolean Society* for 1855; Chancourtois, *Comptes Rendus*, lxiii. p. 22; Lionnet, *Comptes Rendus*, lxiii. p. 213; Favre, *Bibliothèque Universelle* for 1856; Tennant, *Journal of Society of Arts* for 1852, &c.)

DILUVIAL FORMATION [E. C. vol. ii. col. 343]. A term rarely used by geologists. The deposits which were grouped under it are now assigned to the post-pliocene period. The phenomena which were at one time regarded as proofs of enormous floods of water are now attributed to various agencies, as indicated under POST-PLIOCENE PERIOD, E. C. S.

DODO [E. C. vol. ii. cols. 365—373]. When Mr. Broderip, about thirty years ago, drew up his elaborate report on the knowledge then extant respecting the *Dididæ*, he grouped his remarks in three divisions. The first treated of the facts reported in books, the second dealt with those derived from the remains of the birds themselves, while the third contained the views proposed respecting the zoological affinities of the dodo. In 1848 Strickland and Melville adopted the same arrangement, and on the present occasion we propose to follow their example with respect to the few remarks we have to make. In the accounts referred to, the historical and pictorial evidence was far more lengthy than the direct; but now the bones belonging to this group of birds are becoming abundant, and precise information as to the osseous system of more than one species is available.

The first reliable mention of the dodo of Mauritius (*Didus ineptus*) is that by Van Neck; since it appears that the island which Vasco di Gama discovered was visible from the African coast, and that the birds which were called solitaires were penguins. The Dutch voyager to which Clusius refers in col. 366 is J. Van Neck, but the figure is taken from an edition of Neck's Voyages which does not appear to be known in this country. One of the persons who sailed in the fleet of Heemskerk and Harmansz (col. 367), Willem van West Zanen by name, left a journal which was published in 1648, under the editorship of Soeteboom. In this journal the dodo is mentioned, and, as his account is not given in E. C., we append it, as translated in Strickland and Melville's work. "The birds, of which this island [viz., Mauritius] is full, are of all kinds; doves, parrots, Indian crows, sparrows, hawks, thrushes, owls [?], swallows, and many small birds; white and black herons, geese, ducks, dodos, tortoises and sea-cows. The sailors were out every day to hunt for birds and other game, such as they could find on the land, while they became less active with their nets, hooks, and other fishing tackle. No quadrupeds occur there except cats, though our countrymen have subsequently introduced goats and swine. The herons were less tame than the other birds, and were difficult to procure, owing to their flying amongst the thick branches of the trees. They also caught birds which some have named *Dod-aarsen*, others *Dronten*; when Jacob van Neck was here these birds were called *Walleh-Vogels*, because even a long boiling would scarcely make them tender, but they remained tough and hard, with the exception of the breast and belly, which were very good; and also, because from the abundance of turtle-doves which the men procured, they became disgusted with the dodos. The figure of these birds is given in the accompanying plate; they have great heads, with hoods thereon; they are without wings or tails, and have only little winglets on their sides, and four or five feathers, more elevated than the rest. They have beaks and feet, and commonly in the stomach a stone the size of the fist." (Which description Strickland believes is taken from Matelief). . . . "The dodos, with their round sterns (for they were well fattened), were also obliged to turn tail; everything that could move was in a bustle; the fish, which lived in peace for many a year, were pursued into the deepest water pools. . . . On the 25th July, Willem and his sailors brought some dodos, which were very fat; the whole crew made an ample meal from three or four of them, and a portion remained over. . . . They sent on board smoked fish, salted dodos, land-tortoises, and other game, which supply was very acceptable. They were busy for some days bringing provisions to the ship. On the 4th of August, Willem's men brought 50 large birds on board the Bruyn Vis; among them were 24 or 25 dodos, so large and heavy that they could not eat any two of them for dinner, and all that remained over was salted. Another day, Hogeveen (Willem's supercargo) set out from the tent with four seamen, provided with sticks, nets, muskets, and other necessaries for hunting. They climbed up mountain and hill, roamed throughout forest and valley, and during the three days they were out they captured another half hundred of birds, including a matter of 20 dodos, all which they brought on board and salted. Thus were they, and the other crews in the fleet, occupied in fowling and fishing." This is the earliest voyage in which the terms Dodaars and Dronte are applied to the dodo; but it is possible they may have been added by Soeteboom. The earliest book in which the first term is used is that by Verhuffen, published in 1613, where it occurs in the form of *Totersten*. The passage from Herbert in col. 367 is from the edition of his 'Travels' which was published in 1638, which differs materially in orthography, though not in sense, from that of 1634. In a diary of P. Crossfield, a fellow of Oxford University, extending from 1626 to 1640, mention is made of a dodar (a black Indian bird) which was given by Mr. Gosling to the Anatomy School in 1634. It is, hence, supposed there were formerly remnants of two dodos in the museum at Oxford.

There are a few additions to the pictorial evidence. The Duke of Northumberland possesses a picture bearing the monogrammatic signatures of Goimare and De Heem, and the date 1627, in which the ridge at the base of the bill is remarkably well shown. Mention may also be made of the figure in Holme's 'Academy of Armoury and Blazon,' 1688, which represents a dodo as the heraldic device of a family named Dronte. There is also a painting of a dodo in Carisbrook castle which is remarkable for its pure white colour, whereas *Didus ineptus* is always represented as being of a dun or deer colour; and it is conjectured that this may represent the species which frequented Bourbon. In a rare edition of 'Bontekoe's Voyage' there is another figure of a dodo distinct from any previously mentioned, which he says lived in Bourbon, while Strickland suggests that this is a mistake, and that the figure is really that of the Mauritius dodo. Newton, however, points out several points in which Bontekoe's figure differs from those given of the Mauritius bird, and thinks Bontekoe's statement is correct.



In 1865, Mr. Clark, a schoolmaster in Mauritius, reaped the fruits of a long search for dodo remains. He had explored many localities, and had become impressed with the marked traces of denudation which the island presented, due in part to the general looseness of the superficial soil, and in part to the deluging action of the rains. Hence he resolved to confine his researches where the accumulations of recent fluviatile detritus were greatest. His first thought then was to dredge some of the deltas, but it afterwards occurred to him that a marshy tract near Mahebourg, known as the Arum Marsh, or 'Mare aux Songes,' from which bones of deer, turtles, and birds had been obtained, would be worth examining. He employed some men to feel with their feet in the mud where the water was deepest, or about a yard. They soon came upon several leg bones which belonged to the dodo, and subsequent researches brought to light hundreds of osseous remains belonging to every part of the skeleton. Most of them were found in the lowest part of the marsh; were more or less rolled, and seldom associated with turtle bones. Those found at a higher part of the marsh were generally less rolled. None of them exhibited any signs that the birds had been killed or eaten either by man or beasts. The most abundant bones were the tarso-metatarsi; next the tibiæ and pelves; and next the femurs. The sternums were fewer still, but less so than the humeri, coracoids, and scapulæ. The vertebræ were very abundant, but the crania were rare, owing, as is imagined, to the facilities which their sutures and cavities afforded for the disuniting action of growing roots. The bones appeared to belong to one species, but presented two different sizes, due, as is suggested, to sexual peculiarities. Some of the bones had a remarkably black appearance, due to the action of the trunks of ebony trees. From the vegetable remains found, as well as historical and traditionary evidence, it is known that this marsh, and many other parts which are now utterly destitute of trees, were formerly covered with wide spreading luxuriant forests. The old inhabitants state that these forests supplied fruit all the year round. Large quantities of these bones have been sent to Europe, from which a complete, or nearly complete, skeleton has been set up in the British Museum, and of which we give a reduced copy taken from Professor Owen's Memoir in the 'Transactions of the Zoological Society for 1867.' Several more or less perfect sets have been forwarded to other museums, both public and private. Professor Owen's figure, we should mention, is the same size as that by Roland in the British Museum picture, which is said to be of life size. The outline is a correct tracing of that figure; and the bones represent the actual size of those sent to the British Museum by Clark, from which it will be seen how accurately they fit the body which Roland painted. The small figure is *Didunculus strigirostris*, a near ally of the dodo.

The examination of the dodo bones by Professor Owen and Milne-Edwards points to a conclusion very similar to that arrived at by Messrs. Reinhardt, Strickland, Melville, Bonaparte, and others, viz., that this species belongs to the order *Columbæ*, of which type it is an extreme modification. But while some authorities would place it amongst the *Columbidæ*, the general feeling seems to be that it represents a group of similar value to the one just mentioned, and closely allied to it, which bears the name *Didida*. Professor Owen's memoir describes all the bones in detail, enters into elaborate discussions as to the bearing of the osseous structure on its true affinities, and speculates upon the causes which have concurred in producing so remarkable a bird. He considers that the chief characters by which it differs from pigeons generally, are the reflex actions of the surrounding conditions; and that the extinction of the species was due to the abrupt disturbance of those conditions. And although it may present analogies with immature birds, he decidedly opposes the views enunciated by Mr. Strickland as to the cause of the extinction of the dodo. At least, this is the impression we gather from the tone of his remarks; but, as seems to us, the two authorities are really in accord. Thus, Professor Owen says the bird was annihilated because of its degenerate or imperfect structure; while Strickland cautions naturalists against attributing "anything like imperfection to these anomalous organisms, however deficient they may be in those complicated structures which we so much admire in other creatures." As thus stated, their views certainly do not seem to coincide, but they agree, we believe, when their ideas of what *perfection* means is considered. According to Strickland, it consists not in the number or complication of the organs, but in the adaptation of the structure to the external circumstances under which each creature is destined to live. On this view the structure and circumstances are co-adapted one to the other; but if the circumstances alter, so as to be no longer suitable to the species, the bird must either become modified or extinguished. In short, the extinction is due to the organism not being adapted to the circumstances, or in other words, the species is not perfect so far as the new conditions are concerned. Both authors appear to agree that no imperfect animal can thrive.

The views of Professor Owen may be more precisely gathered from what he says in one place respecting the brain, after drawing especial attention to its minute size and to the great development of cancellated structure in the cranium, rivalling that in the elephant's skull. This extreme development of cancellous structure seems to be intended not so much for the protection of the brain as for the acquirement of an extensive surface to which the powerful muscles required for the heavy-weighted head could be attached. "The cerebrum of the dodo does not greatly, and by no means proportionally, exceed the size of that part of the brain in the Crown Pigeon (*Goura*). If the great ground-dove of the Mauritius gradually gained bulk in the long course of successive generations in that uninhabited thickly-wooded island, and exempt from the attacks of any enemy, with food enough scattered over the ground, ceased to exert the wings to raise the heavy trunk; then, on Lamarck's principle, the disused members would atrophy, while the hind limbs, through the increased exercise by habitual motion on land, with increasing weight to support, would hypertrophy. In the long course of generations subject to this slow rate of change there would be nothing in the contemporaneous condition of the Mauritian fauna to alarm or in any way to put the dodo to its wits; being, like other pigeons, monogamous, the excitement even of a seasonal or prenuptial combat, might, as in them, be wanting. We may well suppose the birds to go on feeding and breeding in a lazy, stupid fashion, without call or stimulus to any growth of cerebrum proportionate to the gradually accruing increment of the bulk of the body. Whatever part of the brain was concerned in regulating or controlling muscular action might, indeed, be expected to show some concurrent rate of increase with the growing mass of the voluntary contractile fibres; and the cerebellar division of the cranial cavity accords with the generally accepted physiology of the superincumbent mass of the epencephalon. The lateral depression of the fore and under part of the side of the post-cerebral division of the cranial cavity indicates that the optic lobes, like the eyes, remained almost stationary during the progressive acquisition of the bulk that distinguishes the dodo from the largest existing doves. The proportions of *Didus*, *Pezophaps*, *Casuarius*, *Rhea*, *Dromaius*, *Struthio*, *Aptornis*, *Cnemiornis*, *Palapteryx*, *Æpyornis*, *Dinornis*, &c., among terrestrial birds; of *Notornis* among the lake-haunting coots; and of *Aptenodytes* and *Alca impennis* among sea-birds, point to the disuse of wings in flight as the main condition of increase in size of species of birds, the next condition being the absence of lethal enemies during the years requisite for such course and rate of growth. Let foes arise from whom a power of flight is the main condition of escape, and the wingless giants of the feathered race soon succumb. Among the genera above cited, *Aptornis*, *Cnemiornis*, *Æpyornis*, *Palapteryx*, *Dinornis*, *Didus*, and *Pezophaps*, with the largest of the auks, have thus passed away; while *Notornis* and *Apteryx* are on the verge of extinction, through the rapid increase of population in the small island to which they are restricted. In sparsely peopled continents, such as Africa, South America, and Australia, brevipennate giants may still range the deserts, pampas and unfrequented wilds. The ascertained recent advent of man in New Zealand, New Britain, Ceram, Banda, Salwattie, Mauritius, and Rodriguez, significantly points to the conditions under which have come to pass, in lapse of time, so strange an anomaly as a bird with the specially modified instruments of flight reduced below the power of exerting that mode of locomotion, yet, as a bird, retaining the conditions of the respiratory and tegumentary systems of the volant class, of which it has become a degenerate member. With the cessation of the chief of these conditions, viz., the absence of enemies, such birds necessarily perish."

Milne-Edwards remarks that the dodo is more like the pigeon than any other recent group; and he recognises three principal types, viz., those which are adapted for powerful flight, those which are more suited for terrestrial habits, and those which partake strongly of a gallinaceous character: the last is formed by *Syrrhaptes* and *Ganga*. As the dodo is a ground frequenter, he considers that, were it a pigeon, it ought to differ from the strong-flying species in the same direction as, but to a greater extent than, the ground pigeon; but as the dodo really differs from them by characters of a distinct kind, he is of opinion that the dodo belongs to a non-columbine type. The pelvis has very remarkable features, and differs widely, as pointed out by Milne-Edwards, from the same part in the birds of prey. The author also shows how the other bones are markedly distinguishable from those of the *Struthionidæ* and *Accipitres*, and that although they approximate to those of the columbine group, yet that they constitute a special type by themselves. We are unable to enter into anatomical details, for which we must refer the reader to the investigations of Owen and Milne-Edwards.

A second species of didine bird formerly lived in Rodriguez. It is usually considered to be generically distinct from the dodo, and is known as *Pezophaps solitaria*. Great additions have also been made to our knowledge of the osteology of this bird. In 1865 a collection of its bones were transmitted to England by Mr. Jenner, which he had obtained from the caves at Rodriguez. They appear to represent sixteen or seventeen individuals, and are of two sizes. At one time it was supposed that the larger bones belonged to a distinct species from the smaller, and were assigned to *Didus nazarenus*; but as the corresponding bones resemble each other in everything but size, it is concluded that the larger belong to the male of *Pezophaps solitaria*. Professor Newton refers to other species in which the sexes are unequal in dimensions, such as *Tetrao urogallus* and *Otis tarda*, and shows how the inequality is associated with the peculiar marital habits of these birds [BLACK COCK, E. C. and CAPERCAILZIE, E. C.]. He thinks that, like them, the *Pezophaps* were polygamous, and that the males fought with each other for the females. The strong pectoral muscles and Leguat's description of their habits seem to support this view. The knob mentioned by Leguat has been found attached to several metacarpal bones.

A third species possibly occurred in Bourbon. In 1613 Castleton visited this island, and one of his officers, J. Tatton, mentions a very fat, short-winged bird, which was unable to fly, and which was of a white colour. Carre visited Bourbon in 1668, and refers to a large bird, called the Solitaire, from its love for solitude, whose colour was changeable, verging upon yellow. The variance between Tatton and Carre as to colour may be due to vagueness of expression, and not to any radical difference. Du Bois also refers to the Solitaire of Bourbon as being white. We have already mentioned Bontekoe's statement respecting a dodo in Bourbon, and to the picture of a white dodo in Carisbrook Castle, both of which may belong to the present supposed species. Bontekoe's figure may also be intended for the same bird, although he assigns it to Mauritius. Newton notices that the bird represented in the Carisbrook Castle picture has had its beak trimmed or coped, which would imply that it was kept in confinement. The inside of the mouth is red, the eye is surrounded by a red ring, which may be intended for the iris. In *Didus ineptus* the iris is always coloured yellow. It is further to be remarked that in the Bourbon bird the first four primaries are directed downwards and forwards, while those of the dodo are delineated with a backward direction.

(Clark, G., *Ibis*, new series, vol. ii. pp. 141, 222; *An. des Sciences Naturelles* [3], vol. vi. p. 19; Newton, A., *Proceedings of the Zoological Society* for 1860 and 1865; *Brit. Ass. Reports* for 1866, 1867, 1868; Strickland, *An. Nat. Hist.*, second series, vol. iii. pp. 136, 259; Broderip, *Proc. Zool. Soc.*, part. xxi. p. 54; Owen, R., *Trans. Zool. Soc.* vol. vi.; Milne-Edwards, *An. des Sciences Naturelles*, 5th series, vol. v. pp. 355-380; Newton, *Trans. Zool. Soc.* vol. vi. p. 373.)

E

ELEPHANT [E. C. vol. ii. cols. 501—519]. The genus *Elephas* is now the meagre representative of the order *Proboscidia*, the members of which order have formed so conspicuous a feature in the fauna of Europe from the miocene days to the advent of man. There are two well recognised living species of elephant, namely, *Elephas indicus*, and *E. africanus;* but in 1834 Hodgson suggested that the elephant of Ceylon represented a third species. This opinion has since been supported by Schlegel, who has applied the name *E. sumatranus* to the species inhabiting Sumatra and Ceylon. It is said to differ from the Indian species in having a more slender build, a longer and less robust trunk, and a more bristly, bushy tail. It is more intelligent and docile. Professor Schlegel originally referred to certain differences in the osseous system, which he has since withdrawn as unimportant; such as the greater brevity and narrowness of the free part of the intermaxillaries, the narrower nasal aperture and interorbital space, the greater width of the back-part of the cranium, and the intermediate form of the skull as compared with those of the African and Indian species. The molar teeth possess fewer and broader lamellæ than those of the Indian elephant, but the enamel does not wear down into rhomb-shaped disks as in the African form. It has 20 ribs; the Indian elephant is said to have 19, and the African 21. The caudal vertebræ are 33 in number, or the same as in the Indian species; the African elephant has 26.

Dr. Falconer has endeavoured to show that none of these characters can be relied on as a proof of the distinction of species. Many of the differences, such as slight modifications in the proportions of the body and the trunk, and in the bushiness of the tail, are simply individual or family peculiarities. At any rate, differences of this character occur equally amongst the African or Indian elephants. Amongst Ceylonese elephants it has been observed that the individuals of each herd have such a similarity of feature and appearance as to imply that all are of the same parentage. Thus Sir Emerson Tennent observes that "in a herd of twenty-one elephants captured in 1844, the trunk of each individual presented the same peculiar formation—long, and almost of uniform breadth throughout, instead of tapering gradually from the root to the nostril. In another instance, the eyes of thirty-five taken in one corral were of the same colour in each. The same slope of the back, the same form of the forehead, is to be detected in the majority of the same group." As regards the form of the cranium, Dr. Falconer points out that there must necessarily be slight differences in the degree of development of the intermaxillary bones in order to conform to the varied dimensions of the tusks. He mentions two skulls, the one belonging to an elephant from Ceylon, the other to an individual from Meerut, a locality near the extreme northern range of the Indian species, and states that they agree in general form and proportions as well as in the details of the pyramidal summit, long concave frontal plateau, inial fossa, occipital bones, nasal aperture, position of the orbits, form and connexions of the lachrymary, length of incisive sheaths, &c. On the other hand, when the crania of two well determined species are placed together they present marked differences of form, and numerous distinctive features in the component parts. Professor Schlegel does not precisely state what number of ridges occur in the teeth of the Sumatran elephant, but the materials accessible to Dr. Falconer did not point to any important difference from the Indian elephant. The width of the bands, taken alone, is not a trustworthy character, since it varies with the kind of tooth, the age, and sex of the animal, the degree of abrasion, &c. Dr. Falconer notices one skull of which the penultimate tooth might pass as a typical illustration of *E. sumatranus*, while the last has all the features of *E. indicus*. Moreover the elephants of the Azufgur swamp, at the foot of the Himalayas, have disks of wear such as Schlegel considers to be special to the Sumatran elephant. Dr. Falconer questions the accuracy of the premises upon which Schlegel based his inference that the greater the number of laminæ in the teeth the fewer ribs and dorsal vertebræ did the species have. There appear to be slight variations in the number of ribs possessed by each species. An elephant from Congo which lived for some time in the Versailles menagerie, and whose skeleton was placed soon after the animal s death in the Museum at Paris, had 20 dorsal vertebræ and 20 pairs of ribs. There is the skeleton of a young adult from the Cape of Good Hope in the British Museum in which there are 20 dorsal vertebræ and 20 pairs of ribs. Another specimen, from South Africa, is in the Museum at Saffron Walden; but this had 21 dorsal vertebræ and 21 pairs of ribs; the rest of the skeleton, however, as well as the teeth, agreed exactly with the corresponding parts in the British Museum skeleton. Many, perhaps most, of the known skeletons of Indian elephants have 19 dorsal vertebræ and 19 pairs of ribs; but one specimen, viz., that in the College of Surgeons, which once belonged to Chunee, has 20 dorsal vertebræ and 20 pairs of ribs, according to Dr. Falconer. He states that "the last or nineteenth pair have been lost or omitted in mounting the skeleton. The twentieth dorsal vertebra presents costal articular cups, which are unsymmetrical and small; that on the right-side not much exceeding the size of a silver sixpence. But the vertebra is distinctly present." At Paris there is a skeleton with 20 dorsal vertebræ and 20 pairs of ribs, which was forwarded from Bengal. The result of Dr. Falconer's researches was to convince him that "there is but a single species of Asiatic elephant at present known, modified doubtless according to his more northern or southern habitat, but not to an extent exceeding that of a slight geographical variety."

Taking the elephant of Ceylon as an example of this supposed species, we will attempt to depict its habits as drawn up by Sir Emerson Tennent in his work on the 'Natural History of Ceylon.' So great has been the slaughter of this variety by hunters, ivory traders, and others, that where formerly herds were numerous, now scarcely an individual is to be seen. For many generations the natives used to keep up a system of fires and night watching in order to prevent the intrusion of these massive creatures upon their growing crops, but now so little damage is sustainable from this cause that no precautions whatever are in some places resorted to. Herbivorous in its diet, the elephant delights in the coolness and shades of the forest, where it spends its time harmlessly and peacefully. It is too powerful to be the prey of any other animal, and it molests nothing that does not wilfully interfere with its comfort. As a rule, it manifests no uneasiness at the presence of other animals; but there are a few creatures which disturb its equanimity, such, for example, as the dog and the horse—probably because they are in some way associated with its chief enemy, man. It usually frequents the coolest and loftiest woods of the district which it inhabits. During the day the herds are generally quiescent, the individuals reclining or standing in the midst of the jungle; those in the latter position are generally observed to be in constant motion, or fidgeting much in the same way as in the captive individuals. Thus some will move their head round in a circle, or from one side to another; others will flap their ears, or tilt first to one side and then to the other; others will swing the feet backwards and forwards, or alternately bend and straighten the fore legs; while yet others will fan themselves with a leafy branch, more as it seems for the sake of the motion than for the coolness which they may derive from the operation. Each herd appears to be governed by a leader, which may be either a male or a female, but generally the former, by which all its movements are directed. The leader issues commands, and implicit obedience is always yielded; but what is the method of communication does not seem to be clear. An anecdote by Major Skinner is given by Sir E. Tennent, which will illustrate this statement: "The case you refer to," says the major, "struck me as exhibiting more than the ordinary brute instinct, and approached nearer to reasoning powers than any other instance I can now remember. I cannot do justice to the scene, although it appeared to me at the time to be so remarkable that it left a deep impression in my mind. In the height of the dry season in Neuera-Kalaiva, you know the streams are all dried up, and the tanks nearly so. All animals are then sorely pressed for water, and they congregate in the vicinity of those tanks in which there may remain ever so little of the precious element. During one of those seasons I was encamped on the bund or embankment of a very small tank, the water in which was so dried that its surface could not have exceeded an area of 500 square yards. It was the only pond within many miles, and I knew that of necessity a very large herd of elephants, which had been in the neighbourhood all day, must resort to it at night. On the lower side of the tank, and in a line with the embankment, was a thick forest, in which the elephants sheltered themselves during the day. On the upper side, and all around the tank, there was a considerable margin of open ground. It was one of those beautiful, bright, clear, moonlight nights, when objects could be seen almost as distinctly as by day, and I determined to avail myself of the opportunity to observe the movements of the herd, which had already manifested some uneasiness at our presence. The locality was very favourable for my purpose, and an enormous tree projecting over the tank, afforded me a secure lodgment in its branches. Having ordered the fires of my camp to be extinguished at an early hour, and all my followers to retire to rest, I took up my post of observation on the overhanging bough; but I had to remain for upwards of two hours before anything was to be seen or heard of the elephants, although I knew they were within 500 yards of me. At length, about the distance of 300 yards from the water, an unusually large elephant issued from the dense cover, and advanced cautiously across the open ground to within 100 yards of the tank, where he stood perfectly motionless. So quiet had the elephants become (although they had been roaring and breaking the jungle throughout the day and evening), that not a movement was now to be heard. The huge vidette remained in his position, still as a rock, and then made three successive stealthy advances of several yards (halting for some minutes between each, with ears bent forward to catch the slightest sound), and in this way he moved slowly up to the water's edge. Still he did not venture to quench his thirst, for though his fore feet were partially in the tank and his vast body was reflected clearly in the water, he remained for some minutes listening in perfect stillness. Not a motion could be perceived in himself or his shadow. He returned cautiously and slowly to the position he had at first taken up on emerging from the forest. Here in a little while he was joined by five others, with which he again proceeded as cautiously, but less slowly than before, to within a few yards of the tank, and then posted his patrols. He then re-entered the forest and collected around him the whole herd, which must have amounted to between 80 and 100 individuals, led them across the open ground with the most extraordinary composure and quietness, till he joined the advanced guard, when he left them for a moment and repeated his former reconnaissance at the edge of the tank, after which, having apparently satisfied himself that all was safe, he returned and obviously gave the order to advance, for in a moment the whole herd rushed into the water with a degree of unreserved confidence, so opposite to the caution and timidity which had marked their previous movements, that nothing will ever persuade me that there was not rational and preconcerted co-operation throughout the whole party, and a degree of responsible authority exercised by the patriarch leader. When the poor animals had gained possession of the tank (the leader being the last to enter), they seemed to abandon themselves to enjoyment without restraint or apprehension of danger. Such a mass of animal life I had never before seen huddled together in so narrow a space. It seemed to me as though they would have nearly drunk the tank dry. I watched them with great interest until they had satisfied themselves as well in bathing as in drinking, when I tried how small a noise would apprise them of the proximity of unwelcome neighbours. I had but to break a little twig, and the solid mass instantly took to flight like a herd of frightened deer, each of the smaller calves being apparently shouldered and carried along between two of the older ones."

When the tanks are empty and the river courses are converted into expanses of dry sand, the elephant scoops a hole in the sand with its foot. If the sides were made perpendicular the great weight of the beast would cause the sand to yield. To avoid this inconvenience one side is made with a very low gradient, and it is from this side that it approaches to drink as soon as the water has collected in the hollow through percolation. The depth of the excavation is usually from four to five feet. A considerable quantity of water is imbibed, and a portion of it is stored up probably in a portion of the stomach which appears to be especially adapted for its reception by means of folds and a valvular apparatus. There are many instances on record that the elephant is able to store up a considerable quantity of pure water for many hours. Thus Sir E. Tennent describes the capturing of some herds in a corral; and observes that every individual captured would insert its trunk into its mouth, withdraw a quantity of water from some receptacle, and discharge it over its back. This he saw in the case of a herd which was known not to have had access to water for twenty-four hours. In feeding, the elephant performs every motion with leisurely ease. A tuft of grass is twisted up with the trunk, gently tapped against its foot to get rid of the earth adhering to the roots, and then conveyed to its mouth. A cocoa-nut is deprived of its strong outer covering by rolling under a foot, the fibrous layer next the shell is stripped off with the trunk, and the shell is crushed between the powerful grinders, the milk which flows out being swallowed with intense relish. Elephants are also very fond of the nuts of the palmyra palm, and the stubble of *Chena* lands. *Chena* land consists of forest clearings which are made to raise a single crop and are then allowed to revert to a jungly condition. The patches of growing grain are surrounded by lines of reeds loosely fastened together, which, with the aid of a watcher, effectually prevent the elephants from trespassing. As soon as the crops are ready to be cut, herds are sure to make their appearance, although the time may vary for each district, and wait patiently until the crops have been removed and the watcher withdrawn, when they enter gaps in the fence and feed upon what has been left. Sir E. Tennent says there is something unexplained in the dread which an elephant exhibits on approaching a fence, and the reluctance with which it faces the slightest artificial obstruction. "In the fine old tank of Tissaweva, close by Anara-japoora, the natives cultivate grain, during the dry season, around the margin where the ground has been left bare by the subsidence of the water. These little patches of rice they enclose with small sticks an inch in diameter and five or six feet in height, such as would scarcely keep out a wild hog if he attempted to force his way through. Passages of from ten to twenty feet wide are left between each field to permit the wild elephants, which abound in the vicinity, to make their nocturnal visits to the water still remaining in the tank. Night after night these open pathways are frequented by immense herds, but the tempting corn is never touched, nor is a single fence disturbed, although the merest movement of a trunk would be sufficient to demolish the fragile structure. Yet the same spots, the fences being left open as soon as the grain has been cut and carried home, are eagerly entered by the elephants to glean amongst the stubble.

In the wild state the elephant is eminently fond of luxurious ease; and the same character prevails in the semi-domesticated individuals. It has been said that some elephants will obey the command to perform a task which they have been in the habit of performing without requiring any superintendence. Sir E. Tennent says that if the eye of the keeper is withdrawn the elephant will finish the work immediately in hand, and then leave his work in order to browse, fan himself, and blow dust over his back. The elephant is usually employed in dragging and piling timber, and in moving large stones. When thus engaged and difficulties are encountered, the elephant carefully judges whether the risk is too great or not; and if the latter alternative be adopted it resorts to the most reasonable measures that could be devised for overcoming them without any prompting from men. In this respect the elephant shows greater sagacity than the horse. "His minute motions when engrossed by such operations, the activity of his eye, and the earnestness of his attitudes can only be comprehended by being seen. In moving timber and masses of rock his trunk is the instrument on which he mainly relies, but those which have tusks turn them to good account. To get a weighty stone out of a hollow an elephant will kneel down so as to apply the pressure of his head to move it upwards, then, steadying it with one foot till he can raise himself, he will apply a fold of his trunk to shift it to its place and fit it accurately in position; this done, he will step round to view it on either side and adjust it with due precision. He appears to gauge his task by his eye, and to form a judgment whether the weight be proportionate to his strength. If doubtful of his own power he hesitates and halts, and, if urged against his will, he roars and shows temper." (Tennent.) It is frequently asserted that the elephant is able to uproot or break in half the largest trees of the forest, but this appears to be an exaggeration. The largest elephant in captivity is unable to fell a tree twelve inches in diameter, and hence it is comparatively useless for clearing timber land, but it renders excellent service in piling timber which has already been felled. Thus Sir E. Tennent refers to two specimens employed in piling ebony and satin-wood in the yards attached to the commissariat stores at Colombo. They did their work neatly, and far more quickly than dock labourers could have effected it. When the pile had reached that height that they could not conjointly raise the larger logs to its summit, they leaned two pieces of wood against the heap, and rolled the logs up the inclined plane so formed, and placed them trimly on the top. For most kinds of work, elephant's labour is more costly than that of either the horse or buffalo.

India would seem to have been the head-quarters of the genus *Elephas*; for in no other country does it present so many species, and in none is it so persistent and long enduring. The earliest remains are believed to belong to the early miocene period, since when there seems to have been a constant succession of species. Elephant remains have also been found in the miocene strata of America, and the genus is known to have lasted there up to a late geological period, and possibly even to the time of man, if any importance is to be attached to the traditions of the natives that their ancestors were acquainted with an enormous animal with a snout like an arm. The Chinese also have a similar tradition, as they say there once lived a creature like a rat, but of immense bulk, which frequented the country far away to the north, and which furnished excellent ivory. In Europe, too, it is probable that man may have co-existed with some of the latest forms, as we shall have occasion to mention presently. In this last-mentioned portion of the globe the genus appears to have been an immigrant from other lands, for the first relics do not mount further back in time than the pliocene period. The approximate order of antiquity of the European species is *Elephas meridionalis*, *E. antiquus*, *E. primigenius*, *E. melittensis*, *E. Falconeri*, and *E. africanus fossilis*; and in this order we shall make a few remarks respecting each.

E. meridionalis, Nesti. Its teeth are wide and short, and the laminæ are few and broad. The pattern formed by the projection of the enamel above the softer cement and dentine, consists of a wavy, crimped line, which is usually continuous in the same laminæ, but is not unfrequently broken up into two or more separate valleys. At places the enamel bulges out so that there is an approach to the rhomboidal outline characteristic of the pattern on the molars of the African elephant. The ridge formula of the last milk molar, and of the three true molars, is 8:8, 9, 12. Generally there are from 12 to 13 ridges in action in a triturating surface of about nine inches and a half. Its nearest affinity is with the *E. planifrons* of the miocene of India. The principal localities where its bones have been discovered are the Norwich crag of Norfolk; Bresse, Auvergne, and Velay; at St. Prest, near Chartres; at Viste, near Marseilles; in the province of Asti, Piedmont; in the Val d'Arno, Tuscany; in the trenches of Sebastopol, Crimea; and possibly near Moscow and in Siberia. A fine series of bones belonging to this species is now in the Gunn collection of the Norwich Museum. The bones at St. Prest are marked with striæ and sharp incisions, which Desnoyers avers are analogous to those known to have been formed by means of flint implements. In one example he states there may be perceived traces of arrow marks, such as a sharp triangular notch, and lateral notches produced by the barbs. These markings are not confined to the bones of the elephant, but are equally perceptible on those of associated animals. The horns of the deer have been wrenched from the frontal bones by a violent blow; and many of the marrow bones have been split open. From these and some other facts, Desnoyers arrives at a series of conclusions, of which we will quote three. The first is that the marks upon the most ancient bones appear to have, in great part, the same origin as those of the more modern, and cannot, therefore, be attributed to any other cause than the hand of man. The next is that these facts permit the conclusion, with a very great appearance of probability, until some other more satisfactory explanation better elucidates this double phenomenon, that man lived upon the soil of France before the great and first glacial period—at the same time as the *Elephas meridionalis*, and the other pliocene species of the Val d'Arno in Tuscany; and that he was contemporary with those large animals, anterior to the epoch of the *Elephas primigenius*, and the other mammals, whose bones have been found mixed with the remains of man in the gravels or quaternary beds of the great valleys, and in the caverns. And the last is, that the beds of St. Prest furnish, as yet, the most ancient example in Europe of the co-existence of man with extinct animals. Much, however, depends upon the correct interpretation of the markings. Carnivorous animals are fully able to wrench the horns from skulls, and to crack marrow bones, although they are not known to do it in the systematic way that man effects the operation. As to the striæ, it is not certain that they cannot be produced but with a stone implement. Sir C. Lyell introduced some bones into the beaver's cage at the Zoological Gardens, Regent's Park, and in five minutes he had markings undistinguishable from those upon which Desnoyers had based his conclusions. Proof is still wanting, we think, to show that man was a member of the pliocene fauna.

E. antiquus, Falconer. The molars have more numerous and narrower laminæ than the foregoing species; this is partly indicated by the ridge formula, which is 10: 10, 12, 16. The number of ridges used for triturating at one time is about 14 or 15 in a length of nine and a half inches. It appears to have flourished on the confines of the pliocene and post-pliocene periods in various parts of England, France, Switzerland, Italy, and Northern Africa.

E. primigenius, Blumenbach. The mammoth is more nearly allied to the Indian elephant than any other species. Its molars have a broader crown than those of *E. indicus*, the laminæ are thinner and more numerous, there being as many as 22 or 23 in a triturating surface of nine and a half inches. The ridge formula for the last four teeth of the upper jaw is 12: 12, 16, 24; the last, however, varies, but within certain limits. The difference observable between the molars of the mammoth and the Indian elephant are thus stated by Dr. Falconer:—"Although agreeing in this essential respect, there are important differences in the mechanical disposition of the plates. In *E. primigenius* the molars are shorter for the number of their constituent ridges, and their crowns are also both absolutely and relatively broader than in the Indian species. The alternate successions of cement, enamel, and ivory are therefore more attenuated and more condensed, and a larger number of them enter into the surface of that part of the tooth which is in wear. Lartet fixes the number of ridges that may be in active use at from 20 to 23 in a length of about nine and a half inches; while in the adult Indian elephant the number of bands in the same length is usually about sixteen. But the great difference lies in the mechanical properties of the enamel plates. Instead of being thick and robust, with close set and regular undulations, or zigzags, as in the Indian species, they are thin and parallel, the projecting edges running either straight across, or if there is a tendency to undulation it is but slight, fine, and inconstant; occasionally, even, there is an irregular angular expansion or flexuosity in the edges of the disks that are worn low down; but, as a general rule, the plates are straight, and free from waviness. It is this character which involves the greater width of the molar crown in the mammoth; if the undulations of the Indian elephant were unfolded, the crown plates would in that species be as broad as on the fossil one. Another difference is, that these plates are higher in the mammoth. In the Texan specimen of an upper molar they attain the enormous height of nearly eleven inches. The triturating surface of the crown in the active molar presents another and very significant difference. Instead of the terraced inequalities seen in the molars of *E. Columbi* and *E. indicus*, the worn surface in the mammoth is nearly flat; the enamel edge rising but a little above the ivory and cement. This is a constant character of mammoth molars of all ages, and of all regions, whether from the preglacial 'forest bed' of the Norfolk coast, from the volcanic gravels around Rome, from the superficial gravels of England, from the frozen soil at the mouth of the Lena, from Eschscholtz Bay, from the swamps of Ohio, or the prairie lands of Texas. In fact, the normal condition of the molar crown of the mammoth resembles that of the Indian elephant which has been fed in captivity, but without the distorted arrangement of the plates seen in the latter. This observation, so far as I am aware, has not been made before; and the fact will explain the reason why I have entered so much in detail into the cause of the unnatural condition in the captive Asiatic species." The remarks referred to bear upon the ordinary food of the Indian elephant, and of the derangements caused in the dental system when certain changes are made in the diet. The food, it seems, is partly arboreal and partly herbal. The trees which are most largely employed are the banyan tree, the india-rubber tree, and several others which, like them, abound in a bland milky sap. Amongst the grasses the *Saccharum spontaneum* is a favourite, and the stem of this is so largely charged with silica that to it is due the peculiar mode of wearing of the tooth. "It is difficult," says the authority already cited, "to conceive of a mechanism better adapted to the duty which they have to perform than is presented by the molars of the Indian elephant. Taking the three true molars, which serve during the adult stage of the animal, they are composed successively of twelve, sixteen, and twenty-four ridges. Each ridge has the core formed of a light wedge-shaped plate of ivory; a continuous plate of enamel is closely folded over these wedges, which are confluent at their bases; and the intervals between these ridges are filled up, each with a reversed wedge of cement, which is between the grooves and inequalities of the enamel. When the crown is in full activity of wear, the penultimate molar, consisting of sixteen ridges, presents an unequal triturating surface, composed of thirty-two plates of enamel, alternating with sixteen thin wedges of ivory, and as many of cement, making in all sixty-four alternations, disposed within a length of from 8¼ to 9½ inches. The disintegrating and bruising power of the surface is further greatly augmented by the circumstance that, in the Asiatic elephant, the plates of enamel are folded vertically into a number of bold, close-set zig-zags or undulations, which present a crimped edge during wear. If a number of these plates were brought together so as to place their undulations in contact, an appearance would be produced analogous, on a large scale, to the engine-turning of a watch case, arranged in longitudinal lines. The three constituent materials being of unequal hardness, the cement is worn lowest, the enamel highest, and the ivory to a level between the two. A constant equilibrium is maintained in the normal state between the nature of the food, the waste of the crown surface, the absorption of the fangs, the forward movement of the body of the tooth, and the replacement of the worn-out portion by a succession of fresh plates, protruded from behind." This is what goes on normally in the wild state, but, when the equilibrium is once destroyed, as for instance, by substituting soft substances for hard as food, the molars are worn down slowly, they acquire a smooth, flat surface, the tooth remains for a long time in position without making way for the new comer, the two become agglutinated, and various distortions and diseases arise which produce agony in the animal, and shorten its life. The relation of the nature of the tooth to the kind of food, and the resemblance between the triturating surface of the molars in the Indian elephant to those in the mammoth indicate that their food was similar. But the less corrugated surface of the mammoth's molars seem to indicate that its food was not so hard as that of the Indian species. At present nothing definite has been ascertained as to what plants the mammoth really fed on, although this was one of the principal objects for which the Russian expedition, of which so much has been said lately, was organized. The immense range of the mammoth has been sketched in E.C.; it appears to have extended from Texas in North America as far north as Eschscholtz Bay, through Northern Siberia and Russia, and on to Norway, Sweden, Germany, France, England, and as far south in Europe as Rome. This is the extreme range, but it is probable that only a portion of this space was occupied during one and the same time. Much controversy has been expended as to its true range in time. It appears to be entirely post-pliocene. The earliest English relics have been found in the 'forest bed' at Cromer, and those found in the volcanic gravel beds near Rome seem to be of quite as early a date. The bones found at Kilmaur are also of pre-glacial age. Its remains abound in gravels of post-glacial age. It is noticeable that the bones found in the northern parts of Siberia are usually smaller than those found in the south. Thus teeth found in the Lachow Islands rarely weigh more than three poods, while those found in the south frequently weigh twelve poods. Of late years great efforts have been made by the government and scientific men of Russia to procure a whole carcass of the mammoth. A large reward was offered to any one who discovered a tolerably complete skeleton, and a still larger sum was offered for the finding of a skeleton invested with soft parts. This soon led to the announcement, in 1864, that a large and complete carcass had been seen in Tas Bay, not far from the Jenissei River. An expedition was at once fitted out and provided with ample instructions as to what to do, and how best the animal might be transported to St. Petersburg. The expedition was headed by Schmidt, and the report from him was that the specimen was an imperfect immature individual, and that he was unable to procure any of the contents of the stomach. This much lowered the hopes that had been raised, but it may be expected that the expedition will learn from the country people where a good specimen is to be found. Long accounts about this expedition, and about *E. primigenius*, are contained in the 'Bulletin de l'Academie Impériale des Sciences de St. Petersburg,' vol. x. This volume has a coloured figure of the mammoth, and a reproduction of the carved ivory from the old caves of Perigord on which is delineated a shaggy-haired elephantine creature, surmised to be intended for the present species.

E. melitensis, Falconer. This is a remarkably small species from the caves of Malta, the size of which, when adult, did not exceed that of a large tapir or a small rhinoceros. Mr. Busk estimates its height at about 4 feet 6 inches. Dr. Falconer appears to have been aware of but one pigmy species from the Maltese caves; but Mr. Busk has subsequently ascertained that there are two species. He has reserved the specific name given by Falconer to the larger of the two species. The ridge formula of the teeth is:—

$$\frac{3+5+8}{3+5+8} : \frac{8+9+12}{8+9+12}$$

which comes nearer to that of the existing African species than any other. In the mode of wearing of the teeth there are also resemblances which point to its near affinity with that species; thus, both species present rhomb-shaped patterns; but in the African species the angles terminate in a round loop, whereas this loop is absent in *E. melitensis*.

E. Falconeri, Busk. This is the smaller of the two pigmy elephants from the Zebbug cave, Malta. The ridge formula of its teeth has not been established. The teeth have a general resemblance to those of *E. melitensis*, but there are important differences between them. Mr. Busk has pointed out that there are evidently two distinct types of teeth from this cave, but he is doubtful of the correct specific termination of the two sets. The height of this species, according to Busk's estimate, was from 30 to 36 inches.

Both these species have formed the subject of an elaborate paper by Mr. Busk, published in the 'Transactions of the Zoological Society of London,' vol. vi., p. 227—306. In it descriptions are given of all the bones, and comparisons are made with the corresponding parts of the living forms.

E. africanus fossilis. This species, which is now confined to the central and southern portions of Africa, was known to have extended to its northern borders as late as the fourth century of the present era. But at a still earlier date it must have roamed still farther north, for its remains have been discovered in Spain, France, and various parts of Germany in beds of post-pliocene age.

There is another species, or reputed species, which has once existed in Europe, viz., the *E. armeniacus*, of which specimens have been recorded from Sicily and Italy. It seems to have been nearly allied to the Indian elephant.

(Falconer, Dr., *Natural History Review for* 1863, p. 43—114; *Q. J. Geol. Soc.*, vol. xiii., p. 307; vol. xxi., p. 253—332; Schlegel, *Natural History Review for* 1862, p. 72; D'Archiac, *Faune Quaternaire*, 1865; Brandt, *Bull. Acad. Nat. Sci. St. Petersburg*, vol. x. col. 93, 361; Schmidt, *An. des Sci. Nat.*, 5th Series, vol. vii., p. 82; Lartet, *Bull. de la Soc. Geol.*, 2nd Series, vol. xvi., p. 469; Busk, *Trans. Zool. Soc.*, vol. vi., p. 227.)

ENTOZOA [E. C., vol. ii., cols. 570—578]. Although objections are constantly raised against the name *Entozoa* for the annulose internal parasites, and although *Scolecida* is the term usually substituted for it, we shall, for convenience sake, make our supplementary remarks on the group under the present heading. These remarks, moreover, will be arranged on nearly the same plan as in the original article.

The first order is *Turbellaria*, which has usually been assigned to the Annelidan class, but which some entozoologists consider to form part of the *Scolecida*. There appears, however, to be no certainty as to their true place in the animal scale, but the most correct view seems to be that which would place them intermediately between the *Suctoria* amongst annelids, and the *Trematoda* amongst *Scolecida*. The members of this order are all free, and therefore no further allusion will be made to them here.

The second order is *Cestoidea*, with which the order *Cystica*, mentioned in E. C., vol. ii., col. 572, is identical, since it has been ascertained that the organisms which compose the latter are, for the most part, the immature states of those which are grouped under *Cestoidea*.

The Cestoids, or Tape worms, present some analogy to the *Hydrozoa*, in that the ovum developes into a colony of zooids, and the zooids undergo a series of metamorphoses or changes of form before they acquire the mature condition. They are generally distributed amongst vertebrates, but are comparatively rare amongst reptiles. The zooids or zooid-colonies inhabit different species of animals during the various stages of development, and this migration from one animal to another is an essential feature in their life history. Man is infested by ten species of tapeworm; the *Quadrumana* harbour comparatively few; but the *Carnivora* and *Ruminantia* have them in abundance. The other mammalian orders do not develope many cestoid parasites. Cestoids abound in most families of birds, both those which eat vegetables and those which eat flesh. The fishes have them, but it would seem that large groups are entirely free from these parasites. Cestoids are rare amongst the invertebrates. The number of species is estimated by Cobbold at about 200, which he would group into the three families, *Tæniadæ*, *Bothriocephalidæ*, and *Tetrarhynchidæ*.

The *Tæniadæ* have the head distinctly marked off from the body, with four suckers on its sides, and, in most species, a prolonged portion or proboscis stretching out from the fore end. This proboscis is more largely developed in some species than in others, and its accessory characters are also sporadically distributed. Thus in some species it is retractile, and capable of being withdrawn into a protective sheath; in others it is armed with a crown of horny hooks, the number, position, and size of which frequently furnish marks whereby to distinguish the species. The reproductive pores are marginal and lateral. It embraces the following genera, according to Cobbold:—*Tænia*, Linnæus; *Sciadocephalus*, Diesing; *Ephedrocephalus*, Diesing; *Amphoteromorphus*, Diesing; *Peltidocotyle*, Diesing; *Caryophyllæus*, Gmelin; *Diplacanthus*, Weinland; *Acanthotrias*, Weinland; *Hymenolepis*, Weinland; *Tæniarhynchus*, Weinland; *Echinococcifer*, Weinland; *Proteocephalus*, Weinland; *Dipylidium*, Leuckart.

The *Bothriocephalidæ* differ from most *Tæniadæ* in not possessing a proboscis, and in having the fossæ (which are two or four in number, and arranged opposite one another), provided with hooks which vary in number and grouping. The head is usually distinct, and its shape varies much. The segments and reproductive organs also present great differences. In some species the generative orifices are in the centre of each segment, while in others they are placed at the lateral margin. The species prevail most in the cold-blooded vertebrates. The family includes the following genera:—*Bothriocephalus*, Rudolphi; *Tetrabothrium*, Rudolphi; *Callibothrium*, Van Beneden; *Anthobothrium*, Van Beneden; *Phyllobothrium*, Van Beneden; *Echeneibothrium*, Van Beneden; *Octobothrium*, Diesing; *Diphyllobothrium*, Cobbold; *Solenophorus*, Creplin; *Tricuspidaria*, Rudolphi; *Hygroma*, Schrank; *Echinobothrium*, Van Beneden; *Bothrimonus*, Duvernoy; *Ligula*, Bloch.

Tetrarhynchidæ.—Cobbold describes this family as having four armed retractile proboscides attached to the head. The armature is formed of thousands of sharp pointed recurved hooks. The head is generally bilobed, each lobe having either a bipartite bothrium or two separate pits. The pits are frequently supported on four appendages, which undergo great modification of form through contraction, and have different shapes in different species. The head is not marked off from the body. The body is long, depressed, and composed of distinct segments. The reproductive orifices are situated at the lateral margins of the joints in an irregularly alternate manner. The species are restricted to fishes, the mature forms occurring only in those which feed on other fishes. The following genera are included in this family:—*Tetrarhynchus*, Rudolphi; *Pterobothrium*, Diesing; *Rhynchobothrium*, Rudolphi; *Tetrarhynchobothrium*, Diesing; *Synbothrium*, Diesing; *Stenobothrium*, Leuckart.

Tænia.—This genus affords no fewer than seven species which occur as parasites within the human frame. The most familiar species is the common tapeworm, *T. solium*, of which we append the following description as given by Mr. Cobbold. It is of large dimensions, attaining, when mature, a length of from ten to thirty feet. Larger specimens are on record; but it is believed that these really consisted of several worms associated together. The greatest breadth is about one-third of an inch. The head is about the size of a pin-cap, globular, and produced in front as a short conical proboscis, which is armed with a double circlet of hooks. There are four suckers. The head is marked off from the body by a narrow constricted portion nearly half an inch long. Just behind the constriction the segments are indistinctly annulated by transverse lines, which become more and more spaced apart in proceeding towards the hinder portion of the body. The earliest formed immature segments are very narrow, the proglottis, or sexually mature zooid commencing at about the 450th segment, there being about 800 segments in a worm ten feet long. The mature proglottides are twice as long as broad, thin, and transparent; they are furnished with a branched uterus, which consists of a central stem, with from seven to ten offshoots on either side. Each segment is hermaphroditic; the lateral pores are unquestionably the reproductive orifices. The larval stage was formerly called *Cysticercus cellulosæ*. In addition to the complicated vascular generative system, there is a second series of vessels, which form the aquiferous system. It consists of two longitudinal nodular canals, which divide into four near the head, and are connected at intervals by transverse communication. The life history of a tapeworm is very eventful. The proglottis developes eggs, and these give rise to embryos, which remain for a time within the egg. After a while the proglottis with its young brood is discharged from the body of the individual in which it has been residing; it moves about until the embryos within have become so large that it bursts and sets them free. The embryos are scattered far and wide, wherever wind and water can convey them. A certain proportion of these and of the gravid proglottides are swallowed by pigs. As soon as the embryos find themselves in the pig's digestive canal, they bore through the egg-shell, and into the fatty part of the flesh of their host, by means of a special boring apparatus with which they are furnished, and three pairs of hooks. Having thus attained a position suited to their nature, they lose their boring and anchoring apparatus, and remain in contented ease, until the imperfectly cooked measly pork is eaten by some human individual. Having secured a favourable spot, it attaches itself by means of hooks, and from being a *Cysticercus*, it becomes a *Tænia*. As such it developes a whole colony of zooids, or, in other words, it commences by having comparatively few segments, and gradually developes other segments by gemmation. When mature it partially consists of proglottides similar to those with which we started. Cobbold thus arranges the life phases:—*a*, egg in all stages; *b*, six-hooked embryo or proscolex; *c*, resting larva, or *Cysticercus cellulosæ*, or scolex; *d*, immature tapeworm; *e*, strobili, or sexually mature *Tænia solium*; *f*, proglottis, or free segment. The above is the ordinary routine of development; but, as mentioned in the E. C., the *Cysticerci* themselves may be developed in the human body. *T. mediocanellata* is a second species. It was for long confounded with *T. solium*, until Kuchenmeister pointed out its distinctive character. It exceeds that species in the length, breadth, and thickness of the segments; the head is large, devoid of a proboscis and hook apparatus. It has large sucking disks, which are surrounded by dark pigment granules. The uterine organ has twice the number of lateral branches which occur in the same part in *T. solium*; the branches are more closely packed, and parallel, and have not, consequently, so dendritic an appearance as in the common tapeworm. The first sexually mature proglottis is situated at about the 450th segment. The reproductive papilla is situated much below the centre of the lateral margin. The cysticercal stage is developed in the muscles and internal organs of cattle. This has been experimentally tested by Leuckart, who fed calves with the mature proglottides, and on examining the animals a few weeks after, the muscles were found to contain *Cysticerci*, the heads of which had all the peculiarities of those of the adult *T. mediocanellata*. The experiments were repeated on sheep and pigs, but no results followed. This species is almost as prevalent as the common tapeworm, but the relative numbers of the two depends in a great measure upon the ordinary diet of the people of each country. The Burates, near Lake Baikal feed largely upon the half raw and raw flesh of calves, sheep, camels, and horses; and their meals are eaten without any regard to cleanliness. Hence it happens almost every individual is infested with *T. mediocanellata*, for of 120 individuals which were subjected to *post-mortem* examination only two were free from these parasites. Specimens of *T. solium* are rarely found in the bodies of this people—a fact which is intimately connected with the circumstance that they rarely partake of pork. In this country both species are about equally abundant; but, according to Cobbold, the hooked worm infests the poor, who subsist chiefly on pork, and the hookless worm the rich, who prefer mutton, veal, and beef. *T. acanthotrias* has only been found in the cysticercal stage in a few individuals. *T. flavopunctata* is another rare species; indeed, there is only one instance on record of its occurrence. The proglottides are short, and each segment has a yellow spot centrally situated. The eggs are unusually large. *T. nana* is also rare; its cysticercal state is not known. *T. elliptica* usually has a length of about eight inches. It has a double set of reproductive organs, the outlets of which are placed one on either side at the centre of the margin of each proglottis. The head has an uncinated conical proboscis. *T. marginata* occurs in man in the cysticercal stage, and passes into the dog and wolf in order to acquire its mature state. Dr. Moller swallowed several specimems of *Cysticercus tenuicollis* (the name by which the larval stage was first known), but no injurious effects were produced. The *Cysticercus* is widely distributed, occurring not only in man, but also in monkeys, cattle, sheep, ruminants, horses, swine, and squirrels. All these animals are infested by accidentally swallowing the eggs of *T. marginata*. Its occurrence in man rests upon one solitary case, observed by Schliessner. *T. echinococcus*, which is referred to in the E. C. vol. ii. col. 573, as *Echinococcus hominis*, is the most destructive of all human parasites. It is of small size, rarely exceeding the fourth of an inch in length, and developing three or four segments only. It has a proboscis armed with a double circlet of recurved hooks. The last segment alone developes the generative products, and when mature it is as long as all the other segments put together. The reproductive papilla is situated at the margin, and below the central line. The proscolex developes scolices by internal gemmation. In its earlier phases it frequents the human body, but in the mature form it infests the dog and wolf. The peculiar forms referred to as Acephalocysts in the E. C. vol. ii. col. 572, are the larval states of this species. The earlier development of this tapeworm resembles that of other cestoids. Each adult gives rise to about 5000 six-hooked embryos, which are introduced into the human body in various ways, but chiefly by the agency of water. The majority of them penetrate to the liver, but many take up their quarters in other organs; when settled they are metamorphosed into bladder-like bodies, known as hydatids and acephalocysts. Hence there can be no question that they are of a truly animal nature. In its youngest condition the hydatid is spherical in form and invested in a tough membrane. In four weeks the hydatid has reached a diameter of about one-fiftieth of an inch; and in eight weeks it becomes about one-fifteenth of an inch. It then gives rise to a number of nucleated cells which originate from the external surface of the hydatid itself, but their position is internal relatively to the investing membrane. The cells acquire a multitude of shapes from rotund to stellate, and by agglomeration they form a granular layer. The further changes have not been successively traced; but it is believed that several months elapse before the head is formed. When *Echinococcus* heads are administered to dogs they develope into mature tapeworms in from two to three months, and usually take up their position in the duodenum and small intestines. Long discussions have been carried on by helminthologists as to whether there are one or two species included in the name *T. echinococcus*. This has arisen from the great variety of forms presented by the hydatids, but Cobbold, Leuckart, and others incline to the view that all the forms belong to one and the same species. In the larval condition this species has been found in men, monkeys, sheep, oxen, deer, camels, the giraffe, and various equine and feline animals. Many hypothetical views have been advanced as to the ways in which the *Echinococcus* heads are developed; and as it is difficult to harmonize the conflicting accounts, we give Cobbold's description, and his translation of Leuckart's opinions:—"The first indication (of what is subsequently to become an *Echinococcus* head, or a group of heads) consists of a slight papilliform elevation at the inner surface of the endocyst [or the part which we have referred to above as the hydatid]. This prominence, which does not appear to have been recognized in its very earliest stage, after a short while displays in its interior a vacuole-like cavity, the latter being occupied, however, with a clear limpid fluid. Its margins become more and more defined until the cavity is by-and-by seen to be lined with a distinct cuticular membrane. The papilla, increasing in size, becomes at first elongated or oval, eventually scoleciform, or even, perhaps, a true *Echinococcus* head. Thus far the description bears out, in a measure, the theoretical notions entertained by the older authors; but the developmental process does not stop here, and it is a question if, in any case, it ever does so. The scolex-like development has now (possibly, it may be, not in every case), has now, I repeat, to sacrifice itself by developing in its interior a brood of scolices or *Echinococcus* heads. In other words it becomes gradually transformed into the so-called brood capsules of Leuckart and other authors. All observers who have microscopically examined fresh *Echinococci* must have seen these capsules. Portions of the essential vital endocyst, here forming the outer wall of the brood capsule now thickens in the same way that the original maternal endocyst had done, and these thickened portions, in their turn, become true scolices, or in some cases scolicecoid formations. By a process of inversion (precisely similar to that which has been so often described and figured in the case of *Cœnurus*) the heads are withdrawn, as it were, within the cavity of the brood capsule; and thus the latter displays a bird's nest-like appearance. Frequently, however, a considerable number of them are seen everted, as is shown in one of the highly characteristic figures given by Huxley in his memoir. In this way the developmental process is completed. Before proceeding further, I may here remark that many modifications of this process have been witnessed as regards individual scolices, some of which abort, whilst others, possibly, become new or secondary brood capsules. All those numerous instances where scolices have been seen free in the cavity of the capsules, or in the great general cavity of the maternal hydatid, or in the cavities of the (subsequently to be described) daughter and grand-daughter hydatids, are simply examples of morbid phenomena. They are, in other words, entirely due to *post-mortem* changes. In this condition the scolices are generally quite dead, and therefore, assuredly, do not need a covering of vibratile cilia wherewith to execute their supposed swimming evolutions. In the completely developed state the *Echinococcus* heads exhibit somewhat variable characters as to size and form, the latter difference being for the most part dependent upon their degree of contraction and vitality. In the fully evolved condition they vary from the $\frac{1}{60}$th to the $\frac{1}{100}$th of an inch in diameter, being usually about the $\frac{1}{80}$th of an inch. They are solid throughout, and now exhibit a more or less hour-glass constriction at the centre of the body, which divides the scolex into an anterior part supporting the rostellum and suckers, and a posterior part which has been erroneously compared to the caudal vesicle of ordinary *Cysticerci*. The rostellum supports a double crown of hooks, but the disparity of the two series is scarcely sufficiently marked to render their distinction readily obvious. The hooks of the smaller row vary in size from $\frac{1}{1040}$th to $\frac{1}{1780}$th of an inch, while those of the larger series are from $\frac{1}{830}$th to $\frac{1}{1780}$th of an inch. In all instances, as shown by Leuckart, the root processes are incompletely developed, and, consequently, also vary much in thickness. In some they exhibit peculiar abnormalities, and, on the whole, the *Echinococcus* hooks may be said to be less perfectly formed, in any case, than obtains in the corresponding scolecine or cysticercal conditions of other tapeworms. As regards the other structural features of these larvæ we find the suckers four in number, and the general aspect of the body finely granulated; whilst the observer is invariably struck with the appearances presented by the highly refracting calcareous corpuscles, which more particularly abound at the parietes and inferior part of the scolex. On these bodies I need scarcely dwell, as I have already described their essential features when commenting on the structure of *Cysticercus tenuicollis*. Their size varies, and in Huxley's hydatid from the zebra, they presented an average of the $\frac{1}{2500}$th of an inch only. Huxley even goes so far as to express his belief that 'in the young and normal adult state these peculiar corpuscles are never calcareous, but are composed of an albuminous substance.' This notion as to their earthy character being the results of a degenerative process cannot, as I have said before, be maintained; notwithstanding, it is quite true that all the cestode larvæ exhibit a tendency to calcify, after they have passed the natural limit of their vitality. Having no space to dwell further on this question, it remains for me to observe that a distinct water vascular system is recognizable in these scolices, being also connected by the intervention of the stalk-like neck of the scolex, with the endocystic layer of the brood capsule, and also, therefore, with the vessels of the maternal endocyst. In the scolex, according to Leuckart, there exists a circular channel immediately below the rostellum, and the ring, on either side, gives off two vessels, which pass downwards in a tortuous manner on either side of the scolex, internally, until they arrive at the pedicle where they unite to form two channels, which latter are continued into the vascular system of the maternal endocyst. In the retracted condition of the scolex, their position, of course, becomes very much altered, and they form loops on either side of the central line which marks the space leading down to the now inverted head. Neither Huxley nor myself have seen these vessels in the scolex itself, but Huxley discerned some apparently loose cilia in the granular parenchyma of the body, the longitudinal measurement of these free filaments being about the $\frac{1}{3500}$th of an inch. Further into the morphological changes exhibited by the retracted scolices I need not enter. But now comes the curious question respecting the singular phenomenon termed proliferation. Here also I must be brief, and, to avoid circumlocution, state that the endocyst is, as recently shown by Naunyn, primarily concerned in the production of the secondary and tertiary hydatids, whether they be exogenous or whether they be endogenous. In point of fact, they are specialised developments which, instead of becoming brood capsules, become daughter vesicles and grand-daughter vesicles, constantly developing in their interior secondary and tertiary brood capsules and scolices, but sometimes, it would appear, developing neither the one nor the other. Without attempting a detailed exposition of all these singular and interesting phenomena, I shall adduce a lengthened passage from Leuckart, which will probably sufficiently unfold the complexities of the process. Referring to Naunyn's memoir (which I had myself previously consulted), Leuckart makes the following comment:—'Before I enter,' he says, 'on the formation more especially of the secondary so-called daughter bladders, I will just mention that Naunyn considers the *Echinococcus* heads, as I have also done, as taking their origin, without exception, on the brood capsules, and that in their normal condition they are always connected in one common system with the maternal hydatid. In this respect only is there any difference between us, namely, that Naunyn considers the hollow buds which adhere outside the brood capsules to be inverted and only formed during the cooling [?] of the *Echinococcus* vesicle. In their normal condition the young *Echinococcus* heads were to protrude [?] into the cavity of the brood capsule; consequently they there develope themselves (as Wagener has also described) from the first, and in their subsequent state, with the cuticular layer outside. That both conditions may appear there can be no doubt, and I have particularly stated that I have sometimes found the whole of the buds inverted. In spite of this circumstance I am inclined to consider my view, for the present, the correct one, and in opposition to the view of Naunyn, to consider the premature inverting as exceptional, partly on account of the analogy with the other bladder tapeworms, partly, also, because after the representation of Naunyn (and Wagener) not a single motive can be discovered for the development of *Echinococcus* heads from hollow buds. If the heads were to bud freely in the cavity of the brood capsules from the beginning, then one must explain their later solid formation from the commencement. I have never seen the cilia which, according to Naunyn, are situated on the inner surface of the mother bladders as well as on the brood capsules, but, in other respects, there are hardly any differences of opinion between us as regards the histology of these animals. The more striking, therefore, is the divergence of our views as to the daughter hydatids. It is denied by Naunyn that they take their origin between the lamellæ of the mother bladder; a fact, however, which, in agreement with Kuhl and Davaine, I have seen more than once, and have followed out step by step. The daughter bladders (not speaking of the common sprouting), are said to arise out of heads and brood capsules which grow out gradually and bladder-like beneath the thickening and lamination of their cuticle. I have not the slightest doubt that the author has minutely watched these processes, and I rejoice myself to be able to confirm one method of their formation, namely, the bladder metamorphosis of the scolices (which was not only previously asserted by Bremser, but also by Von Siebold and Wagener). As the author has fully shown, the metamorphosis commences in the hinder part of the body, which, by the expansion of the inner cavity, swells into a bladder-like vesicle, drawing gradually the front part, with its crown of hooks, into it, and (by a thickening of the cuticle, as well as by the uniform distribution of the internal parenchyma), assuming more and more likeness to the *Echinococcus* hydatid. Sometimes one sees developments which are only distinguished from the young *Echinococcus* vesicles by the adhering remnants of the former crowns of hooks.'" The dog is infested by several other species of *Tænia*, the larval forms of which are incapable of living in the human system. The best known species is *T. serrata*, which is a thin band about the fourth of an inch wide, and upwards of four feet in length. Its larval stage is the *Cysticercus pisiformis*, which inhabits the rabbit and hare. The genetic relationship of the form has been demonstrated by Leuckart, who inoculated rabbits with the *Cysticercus* in question by administering to them the proglottides of *T. serrata* taken from dogs, and has traced the successive stages of their development. Cobbold and others have ascertained that if the immature specimens of the *Cysticercus* are given to dogs their further development is arrested. The mature *Tænia* is only developed when the *Cysticerci* are eight weeks old, and when they have encysted themselves for the second time. Another species, which occurs in domestic animals, but not in man himself, is *T. cœnurus*, described in E. C., vol. ii., col. 574, as *Cœnurus cerebralis*. The larval form occurs in the sheep, goat, horse, antelope, deer, dromedary, and rabbit. The mature form infests the dog. That this view is correct is supported by the evidence of Kuchenmeister and others, that when proglottides of *T. cœnurus* from the dog are given to sheep, they soon have *Cœnuri* in their brains, and that when the dogs are fed on the *Cœnuri* thus obtained they become infested with *T. cœnurus*. *Cysticercus fasciolaris*, which occurs in the livers of rats and mice, becomes *Tænia crassicollis* when eaten by cats; and the *Cysticercus longicollis* of the meadow vole developes into the *Tænia crassiceps* of the fox.

Another genus of the same family, viz., *Bothriocephalus*, affords two species parasitic in man. The best known is *B. latus*. It is remarkably broad as compared with *Tænia solium*, assuming a breadth of about one inch, while in length it exceeds that species, frequently reaching to upwards of 25 feet. The head is $\frac{1}{25}$th of an inch across, and has two lateral unarmed grooves. The anterior segments are narrow, and sexually immature, but their width gradually increases in advancing backwards along the colony or body; those near the end are nearly one-fourth of an inch in diameter. There are upwards of 6000 segments, and the sexually mature ones commence at about the 600th from the head. It appears to be restricted to Europe, and mainly to the countries recorded in E. C. vol. ii. col. 574. A few instances have occurred in extra-European localities, but in most cases they were connected with individuals who had just previously travelled in Europe. It is exceedingly common in Switzerland; in one locality, indeed, namely, Geneva, one-fourth of the inhabitants are infested with it. It is common in Russia, Sweden, and Poland; and is not unfrequent in Holland, Belgium, Prussia, Italy, and the south of France. The life history of this species has not been closely traced out. It appears that the egg is oval in form, and is provided with a lid. After an immersion in water of from one to two months the lid is opened, and an active swimming richly ciliated embryo issues forth, and roams about for a few days. The ciliated covering is then discarded, and a six-hooked non-ciliated embryo makes its appearance. Probably the embryo enters some animal wherein to pass its hydatid condition; but what animal performs this nursing function has not been established. *B. cordatus* has been found, though rarely, in the human body. Most of the examples hitherto seen were obtained from North Greenland, and the majority of these were from dogs. It has a short, broad, somewhat heart-shaped head, which is not separated from the rest of the body by a narrow portion. The segments begin to be distinct immediately behind the head, and rapidly increase in width. A large individual consisted of 660 segments, of which the anterior 50 were immature. Amongst the more important species which frequent animals, but not man, may be mentioned *B. nodosus*, which passes its larval stage in the bodies of fresh-water fishes, and arrives at the mature condition within herons, gulls, and other aquatic birds. As in most other entozoa, the segments do not develope into maturity until they have reached a suitable position, which is usually the intestine of some animal. Hence many individuals die without sexually produced progeny, in consequence of accidents preventing their following the requisite migratory course. *Diphyllobothriun stemmacephalum* is parasitic within the intestines of the porpoise. *Triænophorus* is now called *Tricuspidaria*, of which genus only one species, *T. nodulosus*, is known.

The researches made by Krabbe on the entozoic parasites of Denmark and Iceland have brought out in strong relief a fact which has been indicated by previous observers. It is that the prevalence of tænoid worms depends largely upon the abundance of dogs, cattle, and sheep, relatively to the human population, and upon the degree of care with which the requisite sanitary precautions are carried out for preventing the access of entozoic larvæ to these domestic animals. In Iceland they far outnumber the population, and this, together with the utter want of sanitary precautions, is connected with the great prevalence of parasites in Iceland. The occurrence of houseless dogs in any country is a nuisance; nay, more than this, it is a pest to society. These animals eat any garbage, and frequently become infested with parasites; and these parasites are liable to be transferred to any one who has anything to do with these animals. A single dog may, under favourable conditions, impart tapeworms to hundreds of individuals. Domestic dogs should be kept thoroughly clean, fed upon sound meat, and prevented from drinking water which contains sewage, or which has been directly derived from superficial drainage.

The order *Trematoda* comprises at least 400 species, which Cobbold arranges under five families, viz., the *Monostomidæ*, *Distomidæ*, *Tristomidæ*, *Polystomidæ*, and *Gyrodactylidæ*. As the names indicate, the number of pores or oral suckers is mainly relied on as the family character.

The *Monostomidæ* have a single anterior pore, a character which is precisely the same as is assigned to the genus *Monostoma* in E. C. vol. ii. col. 575. The digestive system consists of an œsophagus, from which diverge two large cæcal canals, which sometimes end in two separate blind ends, but are sometimes blended together into an arch. The individuals are hermaphroditic. There is a well-defined water vascular system, but the nervous system, although probably present, has not been detected. The young are produced oviparously, ovo-viviparously, and viviparously. The last mode has been seen in *Monostoma mutabile*. In it the young leaves the egg shell as a ciliated embryo while still within its parent. The embryo developes by internal gemmation larvæ which have a form quite distinct from the embryo, and from the embryo's parent. In this state the embryo leaves its parent, swims about for a while as an independent being, and gives birth to the larvæ within it. These encyst themselves, and develope the forms which were formerly grouped as the genus *Cercaria*. The actual transformation of the *Cercariæ* of this family into mature monostomes has not been traced; but the phenomena observed in allied families fully support the supposed genetic relationship indicated. There are two genera, *Monostoma*, Zeder; *Neuratobothrium*, Van Beneden, neither of which afford human parasites.

The *Distomidæ* have two pores, situated as described under *Distoma*, E. C. vol. ii. col. 575. The life history of the species of this family is remarkably curious, and has been fully investigated in *Distoma militare*. The sexually mature individual produces a number of eggs. Each egg undergoes the usual process of segmentation, and gives origin to a free-swimming ciliated embryo. The embryo produces by internal gemmation an organism called a sporocyst or a scolex. The sporocyst has traces of a head, and a cæcal digestive tube running through the main portion of the body. The caudal end is slightly bilobed. As growth proceeds, the head and body become more clearly defined, and the lobed condition of the posterior end is more clearly pronounced. A sucker soon after appears at the anterior end, and communicates by a passage with an œsophageal bulb, and through it with the digestive canal. At this early stage a number of *Cercariæ* are formed in its interior by gemmation. At first they are long oval masses, but they are soon provided with cephalic and ventral suckers, a rudimentary digestive system, a forked tail, and other features which occur in the adult *Distoma*. When the *Cercariæ* have escaped from the sporocyst, they have an oval sucker, a pharyngeal bulb, an œsophagus, two alimentary cæca, a ventral sucker, a water vascular system, with which is connected a contractile vesicle, and a highly developed marginally fringed tail. In this state they swim about for a while, and then, after parting with their tails, they encyst themselves on or in the body of an aquatic mollusc or insect. The encysted larvæ, or pupæ as they are frequently called, acquire a series of cephalic hooks, and undergo other changes. The cysts are taken into the intestines of some vertebrate animal, and then other transformations occur. In this stage the creatures have a mouth, a cephalic sucker, a pharyngeal bulb, an œsophagus, digestive cæca, coronal spines, a contractile vesicle, an aquiferous system, the matrices of yelk forming glands, and a mass of cells, from which the reproductive organs are subsequently differentiated. Other changes of considerable magnitude occur before the sexually mature condition is attained. As in other families, it appears that development only proceeds when the larval forms are transferred from a few definite species of animals to certain others. The *Cercaria ornata* is the larval stage of *Distoma clavigerum;* and *Cercaria armata* of *Distoma endolobum*. The genera belonging to this family are: — *Fasciola*, Linnæus; *Campula*, Cobbold; *Distoma*, Zeder; *Dicrocœlium*, Dujardin; *Bilharzia*, Cobbold; *Köllikeria*, Cobbold; *Crossodera*, Dujardin; *Echinostoma*, Dujardin; *Gasterostoma*, Von Siebold; *Wedlia*, Cobbold; *Codonocephalus*, Diesing; *Eustemma*, Diesing; *Holostoma*, Nitzsch; *Hemistoma*, Diesing; *Diplostoma*, Nordmann; *Rhopalophorus*, Diesing; *Amphistoma*, Zeder; *Amphiptyches*, Grübe and Wagener; *Tylodelphys*, Diesing.

The *Tristomidæ* have the external appearance of leeches combined with the internal organisation of trematodes. They have two anterior suckers and a posterior one. The mouth is situated between the two anterior suckers, and communicates with a dendritic intestine, the branches of which terminate cæcally. The individuals are hermaphroditic, and the reproductive organs are formed on the same type as those of other flukes. In their habits they resemble the marine leeches, attaching themselves as external parasites to fishes and crustaceans, generally selecting a place on the gills. Little appears to be known as to the mode of development in this family, but in the genus *Udonella* there appears to be very little polymorphism. The genera assigned to the *Tristomidæ* are *Tristoma*, Cuvier; *Epibdella*, Blainville; *Udonella*, Johnston; *Encotyllabe*, Diesing; *Calicotyle*, Diesing; *Benedenia*, Diesing; *Notocotyle*, Diesing. The genus *Pseudocotyle* of Beneden and Hesse appears to belong to this family, although it does not conform to the family as above defined. It has no anterior sucker, and the posterior one is not provided with hooks.

The *Polystomidæ* have several suckers, a ramified intestine, a trematode type of reproductive organs, a water vascular system, and an armature of prehensile hooks. The following genera belong to this family:—*Polystoma*, Rudolphi; *Plectanophorus*, Diesing; *Diclibothrium*, Leuckart; *Solenocotyle*, Diesing; *Octobothrium*, Leuckart; *Axine*, Abildgaard; *Onchotyle*, Diesing; *Diplozoon*, Nordmann; *Grubea*, Diesing; *Cotylaspis*, Leidy; *Aspidocotyle*, Diesing; *Aspidogaster*, Von Baer.

The *Gyrodactylidæ* are ectoparasitic animals, like the members of the last family, but unlike them its species have but one caudal disk, which is generally associated with one or many hooks, and a series of tentacles, all of which subserve a prehensile function. Each species of parasite is usually confined to one species of fresh-water fish. The greatest variation occurs in connection with the hooks. It embraces the genera *Gyrodactylus*, Nordmann; *Dactylogerus*, Diesing; *Calceostoma*, Van Beneden; *Tetraonchus*, Diesing; *Diplectanum*, Diesing.

Nearly one-third of the species parasitical in man belong to the order *Trematoda*. The first we will notice is *Fasciola hepaticum*, which is described as *Distoma hepaticum* in E. C. vol. ii. col. 575. It has not only been found in the gall-bladder, but also just beneath the skin in various parts of the body. The full-grown fluke sometimes contains as many as 45,000 eggs. Each egg developes into a free-swimming ciliated embryo of a long conical form, with a truncate anterior extremity, a central proboscis-like papilla, and a bluntly-pointed posterior end. After a while the cilia are discarded, the embryo changes to an oval form, and progresses by reptation only. Beyond this the development has not been followed, but it may be surmised that the embryo passes through the *Cercaria* and pupa stage before arriving at maturity. This species produces but little direct injurious effect upon man; but it is the cause of great mortality amongst sheep, hundreds of thousands of which have been thus carried off in a single year in England alone.

Distoma lanceolatum is of small dimensions, rarely attaining a length of half an inch, and a maximum breadth of a line and a half. It is frequently met with in the sheep and ox, but it also occurs in red-deer, fallow-deer, rabbit, and cat. It is rare as a human parasite. *Distoma ophthalmobium*. Some immature specimens of this species have been extracted from the lens of a young child. *D. crassum* has been found once only in a human subject. *D. heterophyes* has occurred a few times as a human parasite.

Bilharzia. This genus is represented by one human parasite, viz., *B. hæmatobia*, which has been found in the blood-vessels of persons residing in Africa, as also of African monkeys. It is very common in Egypt, where, according to Bilharz, nearly one-half of the adults are more or less infested with it.

Tetrastoma renale has been obtained from the kidneys of a woman resident at Capodimonte.

Hexathyridium pinguicola, described in E. C. vol. ii. col. 575, as *Polystoma pinguicola*, has not been recorded as a human parasite since Treutler's observation. A second species, *H. venarum*, is, however, better known. Specimens were first obtained by Treutler from the blood of a young man; subsequently Delle Chiaje saw specimens in the saliva of two persons suffering from hæmoptysis, and Follina has noticed it in venous blood.

Of the *Acanthocephala* little further need be said, as no human parasites belong to it. It still consists mainly of but one genus, *Echinorhynchus*, which comprises about one hundred species. The individuals undergo metamorphosis, and pass through several animals belonging to different species while progressing towards maturity. Lindemann has recently founded a second genus, *Paradoxites*, for two remarkable species from the intestines of *Strix passerina*.

The order *Nematoidea* is more numerous in species than any of the others, more than 800 having been described, although it is probable that of these not more than 550 are entitled to acceptation. Cobbold classes them in eight families, named respectively *Anguillulidæ*, *Gordiidæ*, *Oxyuridæ*, *Filaridæ*, *Cheiracanthidæ*, *Ascaridæ*, *Strongylidæ*, and *Cucullanidæ*.

The *Anguillulidæ* are found sometimes in vegetable matter undergoing fermentation, and sometimes as parasites within earthworms, mollusks, the larvæ of insects, batrachians, and fishes. They appear to be endowed with the power of vitality after having been subjected to a thorough desiccation or refrigeration. Indeed it is said specimens of *Anguillula tritici* have revived after having been dried up for four years. The family embraces the genera *Anguillula*, Ehrenberg; *Pontonema*, Leidy; *Enoplus*, Dujardin; *Urobales*, Carter; *Amblyura*, Hemprich and Ehrenberg; *Odontobius*, Dujardin; *Diplogaster*, Schultze; *Dorylaimus*, Dujardin; *Phanoglene*, Nordmann; *Dicelis*, Dujardin; *Phacelura*, Hemprich and Ehrenberg; *Leptodera*, Dujardin; *Pontonema*, Diesing; *Isacis*, Lespes; *Nema*, Leidy; *Hemipsilus*, Quatrefages; *Potamonema*, Leidy.

A most important monograph of this family has been published by Bastian in the 'Transactions of the Linnean Society,' vol. xxv., in which many new genera, and about a hundred new species are described. His list of genera is so much fuller than that of Cobbold that we give a tabular view of them here.

I.—LAND AND FRESHWATER.

Spicules two, equal, with or without a single posterior median accessory piece.

* Integument plain, or with longitudinal markings. No ventral excretory gland.
  † Caudal sucker small.
    1. Pharyngeal cavity none. Œsophagus cylindrical . . . . *Monhystera.*
    2. Pharyngeal cavity large, with one upper tooth-like projection. Canal of œsophagus indicated by three bright lines . . *Mononchus.*
    3. Pharyngeal cavity cup-shaped; no teeth; œsophagus having three lobes of termination. *Trilobus.*
  †† Caudal sucker absent.
    4. Pharyngeal cavity small, long, and narrow. Œsophageal canal bounded by three bright lines . . . . *Ironus.*
    5. Œsophageal canal as in 4. Spear exsertile at its commencement . . . *Dorylaimus*, Duj.
    6. Œsophagus with oval swelling at its termination, containing a single valvular apparatus. *Anguillula*, Ehr.

** Integument with transverse striæ. Ventral gland present or absent.
  † Caudal sucker present.
    7. No pharyngeal cavity. Œsophagus with constricted portion at termination . . *Tripyla.*
    8. Pharyngeal cavity cup-shaped, with small horny plates at bottom. Œsophagus with large muscular swelling at middle of its length. *Diplogaster*, Schultze.
    9. Pharyngeal cavity long and narrow. Œsophagus with oval swelling at its termination, with complex valvular apparatus. Ventral gland opening by twisted duct near middle of œsophagus . . . . *Plectus.*
    10. Œsophagus terminating in a large round muscular swelling. Ventral gland opening posterior to termination of œsophagus . *Aphelenchus.*
  †† Caudal sucker absent.
    11. Œsophagus with rounded swelling posteriorly, containing a simple valvular apparatus. Ventral gland opening as in 10. Males with caudal alæ . . . . *Cephalobus.*
    12. Œsophagus with rounded swelling about its middle. Ventral gland opening as in 11. Caudal alæ narrow, unsupported *Tylenchus.*
    13. Pharyngeal cavity cylindrical. Œsophagus with elongated swelling at middle, and a rounded one at termination, as in 11. Caudal alæ large, supported by rays . . *Rhabditis*, Duj.

II.—MARINE.

Spicules two, equal, solitary or with 1, 2, or 4 accessory pieces. Occasionally a single supplemental organ in ventral region above anus. Ventral excretory gland present in all (?). Caudal sucker universal.

* Integument plain, or with longitudinal markings; œsophagus embraced by glandular (?) ring.
  † Spicules solitary, or with a single posterior median piece.
    14. Pharyngeal cavity long, complex, crossed by lines or bars, with a funnel-shaped body on its inferior aspect . . . . . *Symplocostoma.*
    15. Pharyngeal cavity large, with three tooth-like projections . . . . . *Oncholaimus*, Duj.
    16. Pharyngeal cavity none . . *Enchelidum*, Ehr.
    17. Integument having a row of opposite setæ on dorsal and ventral surfaces. Ocelli none. *Anticoma.*
    18. Pharyngeal cavity small. Ocelli distinct and lateral . . . . *Phanoderma.*
  †† Spicules having two equal accessory pieces.
    19. Pharyngeal cavity none. Ocelli distinct, dorsal. Excretory glandular organs two, opening on either side of the head . . . *Leptosomatum.*
    20. Pharyngeal cavity indistinct, surrounded by three separate teeth. Ocelli not distinct. No œsophageal ring, and integument with delicate transverse as well as longitudinal striæ. *Enoplus*, Duj.
    21. Pharyngeal cavity cup-shaped. Œsophagus enlarged behind pharynx. Anal glands large. Accessory pieces recurved . . *Linhomœus.*

** Integument with transverse striæ or dots. No œsophageal ring.
  † Ocelli absent.
    ‡ Uterus unsymmetrical.
      22. Pharyngeal cavity absent. No vaginal glands. *Tachyhodites.*
      23. Pharyngeal cavity hemispherical; vaginal glands two, unequal . . . . *Theristus.*
      24. Pharyngeal cavity large, somewhat spherical. Vaginal gland single, posterior . *Sphærolaimus.*
    ‡‡ Uterus symmetrical.
      25. Pharyngeal cavity very small. Spicules with or without a very small posterior accessory piece . . . . *Comesoma.*
      26. Pharyngeal cavity none. Spicules stout, curved, with two accessory pieces . . . . *Spira.*
      27. Pharyngeal cavity none. Teeth doubtful. Spicules as in 26 . . . . *Odontobius*, Roussel.
  †† Ocelli present or absent.
    28. Œsophagus cylindrical. Accessory pieces strong, in two pairs . . . . . . *Cyatholaimus.*
    29. Œsophagus having well-marked swelling posteriorly. Accessory pieces two, rather indistinct . . . . *Spiliphera.*
    30. Pharyngeal cavity rather indistinct. Accessory pieces two, strong, hooked . . *Chromadora.*

The *Gordiidæ* are filiform, and are provided with a mouth and intestinal canal, which latter terminates cæcally; and in some of the species the digestive system is even more rudimental than is indicated here. Thus *Filaria rigida* and *Sphærularia bombi* are said to have no intestines at all. The sexes are distinct. The genera belonging to this group are *Gordius*, Linnæus; *Mermis*, Dujardin and Siebold; *Acicula*, Renier; *Dracunculus*, Lister; *Sphærularia*, Dufour; and *Anguillina*, Hammerschmidt.

The *Oxyuridæ* have fusiform bodies, a rounded oral aperture, a triquetrous or three-cornered œsophagus, and a highly developed nervous system. The genera assigned to this family are, *Oxyuris*, Rudolphi; *Ptychocephalus*, Diesing; *Pharyngodon*, Diesing; *Mastigodes*, Zeder; *Heterakis*, Dujardin; *Subulura*, Molin; *Cosmocerca*, Diesing; *Thelastoma*, Leidy; *Streptostomum*, Leidy; and *Allodapa*, Diesing.

The principal genus of the *Filaridæ* has been the resting place of many species of entozoa which have little relationship with it beyond a similarity of outward form. Hence the definitions which have been given of it have been sufficiently diversified. Cobbold would apply the family title to all those nematoids which have the "body filiform, smooth, or finely striated transversely, furnished with a simple round or triangular mouth, generally surrounded by a variable number of papillæ; head continuous with the body, anus terminable or nearly so, tail of the male obtuse, bluntly pointed or slightly expanded, penis consisting of a long spiculum, which is often accompanied by a short accessory piece." As thus defined, it would include the following genera:—*Monopetalonema*, Diesing; *Gongylonema*, Diesing; *Dicheilonema*, Diesing; *Tricheilonema*, Diesing; *Tetracheilonema*, Diesing; *Filaria*, Müller; *Dracunculus*, Kaempfer; *Ichthyonema*, Diesing; *Dipetalonema*, Diesing; *Solenonema*, Diesing; *Filaroides*, Van Beneden; *Trichosoma*, Dujardin; *Capillaria*, Zeder; *Tricocephalus*, Dujardin; *Onchophora*, Diesing; *Thominx*, Dujardin;

Eucoleus, Dujardin; *Calodium*, Dujardin; *Liniscus*, Dujardin; *Sclerotrichum*, Rudolphi; *Onchocerca*, Diesing; *Trichina*, Owen; *Eucamptus*, Dujardin; *Proleptus*, Dujardin; *Simondsia*, Cobbold; *Spirura*, Blanchard and Leidy; *Dispharagus*, Dujardin; *Tropidocerca*, Diesing; *Spiropterina*, Van Beneden; *Cheilospirura*, Diesing; and *Physocephalus*, Diesing.

Cheiracanthidæ is the name given to the nematoids which have the head distinctly marked off from the body, a spiny integument, and one or two spicula. The genus *Heterocheilus* (Diesing) is referred to this family, although it has no spiny developments on the skin. The other genera belonging to the family are *Cheiracanthus*, Diesing; *Liorhynchus*, Rudolphi; *Lecanocephalus*, Diesing; *Ancyracanthus*, Diesing; *Aspidocephalus*, Diesing; *Echinocephalus*, Molin; *Hystrichis*, Diesing; *Hystrignathus*, Leidy; *Conocephalus*, Diesing; *Ancyracanthopsis*, Diesing; *Elaphocephalus*, Molin; *Stenodes*, Dujardin; *Cosmocephalus*, Molin.

Ascaridæ. The species which Cobbold considers ought to be placed in this family are those which have a trivalved oral aperture, and the males of which have a double spiculum. The body tapers towards either extremity, its surface being marked with transverse striations, and two or four longitudinal lines, which correspond with the water vascular and nervous systems. The sexes are sometimes equal, and sometimes inequal, in size; in cases where inequality exists it is the male which is the smaller. For example, the sexes of *Ascaris lumbricoides* are both 150 mm. in length; in *A. mystax* the female is 200 mm. long, and the male only 90 mm.; and in *A. quadrangularis* the female measures 150 mm. and the male but 67 mm. The family includes the genera *Ascaris*, Linnæus; *Heterakis*, Dujardin; *Heligmus*, Dujardin; *Peritrachelius*, Diesing; *Acanthocheilus*, Molin; *Crossophorus*, Hemprich and Ehrenberg; *Atractis* (?), Dujardin; *Ozolaimus*, Dujardin.

The *Strongylidæ* are round, filiform, and long in shape, possess a round, oval, or triangular mouth, which is sometimes provided with an armature on the pharynx, consisting of one or several pieces, and comprise the genera *Strongylus*, Müller; *Uncinaria*, Froelich; *Eustrongylus*, Diesing; *Sclerostoma*, Rudolphi; *Dochmius*, Dujardin; *Prosthecosacter*, Diesing; *Stenurus*, Dujardin; *Diaphanocephalus*, Diesing; *Stephanurus*, Diesing; *Deletrocephalus*, Diesing; *Dicentrocephalus*, Wedl.

The *Cucullanidæ* are closely allied to the previous family, but differ from it in not possessing a bursa, and in having a differently shaped mouth. The head is broad and obtusely rounded in front, the pharynx is bivalvular, and there is usually a preanal sucker. The genera are *Cucullanus*, Müller; *Angiostoma*, Dujardin; *Dacnitis*, Dujardin; *Pleurorhynchus*, Naudyn; *Ophiostoma*, Rudolphi; *Rictularia*, Frölich; *Hedruris*, Nitzsch; *Symplecta*, Leidy; *Stelmius*, Dujardin.

The Nematoid order affords twelve species which are parasitic within the human frame, to each of which we will devote a few remarks:—*Ascaris lumbricoides* is now generally considered to be distinct from the allied worm which infests the horse and hog. The former is known as *A. megalocephala*, and the latter as *A. suilla*. In *A. lumbricoides* the mouth consists of three lobes or papillæ, which have a number of denticles on their internal surfaces, and which act together to form a single sucker. It leads to a large and muscular œsophagus, which is separated by a constriction from the rest of the digestive canal. This canal terminates in a cloacal cavity, which communicates with the external medium by means of a transverse slit near the extremity of the body. The skin presents a series of longitudinal and oblique lines which have frequently been regarded as muscular fibres; but Cobbold, Bastian, and others think they have nothing to do with the muscular system. In the present species this system consists mainly of four longitudinal bands, of which two are dorsal, and two are ventral. The general cavity of the body contains a number of loose parenchymatous cells, which are generally bathed in a red-coloured nutritive fluid. Little that is definite and trustworthy has been ascertained respecting the nervous system. According to Schneider the allied species *A. megalocephala* has a ring near the oral aperture, from which ring six nerves pass off in a forward direction; while two larger nerves take a backward course, but they are soon lost in the tissues of the body. *Ascaris mystax* is a worm which has long been known as a parasite in the cat, but it is only recently that it has been established that this species is the same as the human parasite, known under the name *A. alata*. It is distinguishable by the wing-like appendage on either side of the head. The male rarely exceeds a length of two inches and a half, while the female is generally upwards of four inches. The male has a tendency to assume an arcuate form, the tail being more curved than the body; the female shows the same tendency, but in a less marked degree. *Trichocephalus dispar*. The capillary portion alluded to in E. C. vol. ii. col. 577, is the narrow anterior end of the body. The species appears to be very frequent in France, for, according to Davaine, at least one half of the inhabitants of Paris are infested with it. In England it seems to be comparatively rare. *Filaria lentis*. This is the same as the species named *F. oculi humani* in E. C. vol. ii. col. 576. Several cases of its presence in the eye have been recorded since Nordmann's observations were published, but as all the specimens have proved to be immature, it is not improbable they may represent several distinct species; at any rate there are no good grounds for accepting them as specifically identical. *F. trachealis* is the larval form of some unknown species, probably of *Ascaris*, which has been met with in the trachea of a patient. *Trichina spiralis* is one of the few nematoids which has been subjected to a thorough study. It has been popularised by repeated exhibitions under the microscope at our evening soirees, and by numerous pamphlets and memoirs, of which the most important are, Leuckart's 'Untersuchungen über *Trichina spiralis*,' 1860; Virchow's 'Darstellung der Lehre von der Trichinen,' 1864; Althaus's 'Essay on Trichinosis,' 1864; Pagenstecher's 'Die Trichinen,' 1866. In addition to these there are a host of papers scattered through numerous scientific and medical periodicals. Cobbold describes it as "an extremely minute nematode helminth, the male in its fully developed and sexually mature condition measuring only the $\frac{1}{18}$th of an inch, whilst the perfectly developed female reaches a length of about $\frac{1}{8}$th of an inch; body rounded and filiform; usually slightly bent upon itself, rather thicker behind than in front, especially in the males; head narrow, finely pointed, unarmed, with a simple central, minute oral aperture; posterior extremity of the male with a bilobed caudal appendage; the cloacal or anal aperture being situated between these divergent appendages; penis consisting of a single spicule, cleft above, so as to assume a **V**-shaped outline; female stouter than the male, bluntly rounded posteriorly, with the genital outlet placed far forward at about the end of the first fifth of the long diameter of the body; eggs measuring $\frac{1}{1480}$th of an inch; mode of reproduction various." This description refers to the mature entozoon, while that given in E. C. vol. ii. col. 578, applies to the immature state only. The adult *Trichina* dwells in the muscles of the same animals as carry the larvæ, and amongst such bearers there may be mentioned in addition to man, the dog, the cat, the rabbit, the rat, the mouse, the guinea pig, the horse, ox, sheep, and other ruminants. The embryos, after leaving their parents, which generally take up their quarters in the intestines, make their way into the muscles of their host, and seldom stop in any non-muscular tissue. Leuckart's view respecting the *Trichina spiralis* is that it is the juvenile form of a little round worm for which the name *Trichina* should be retained, and that this mature form inhabits the intestinal canal of man and other mammalia. The *Trichinæ* attain maturity within two days of their introduction into the intestines. The eggs are developed, while yet within the parent, into *Filaria*-like embryos, which are born on the sixth day. When liberated they penetrate through the intestine and the abdominal cavity into some muscles. They generally follow the course of the inter-muscular connective tissue, and the majority stop in the muscles which are nearest the abdomen and thorax. In fourteen days after having settled down in a muscle the larva has acquired the size and stage of development presented by the *Trichina spiralis* in its best known state. The worm acts upon the muscular tissue, and causes its fibrillæ to granulate, its corpuscles to change into oval nucleated cells, and subsequently its sarcolemma to thicken and shrivel. The space occupied by the parasite acquires a spindle-shaped outline, and within it the entozoon encysts itself within a globular calcified cyst. Serious consequences sometimes result from the simultaneous migration ot a large brood of *Trichinæ*; thus peritonitis is brought about by the perforation of the intestinal walls with thousands of holes, paralysis results from the destruction of the muscular fibres, and general debility is sometimes produced by the myriads of minute worms draining off the nutritive fluids of the individual for their own support. Indeed these tiny creatures induce a special form of disease, which has been designated *Trichiniasis*. Although the life history of this species has not been followed out, there can be little doubt that the pig plays an important part in keeping up the stock, and in imparting *Trichina* to human beings. Hence it will be seen how important it is for the public health that pigs, and indeed most domestic animals, should be subjected to strict sanitary regulations. The case will perhaps be rendered clearer if we mention that one individual may harbour thirty millions of *Trichinæ*, and if we quote the following remarks from Dr. Gamgee, which indicate how people may become attacked by trichiniasis, as well as how they may guard against it. "It is interesting to observe that parasitic maladies in the pig specially abound in that section of the United Kingdom where swine live most amongst human beings. The Yorkshire and Berkshire pigs, in their native counties, inclosed in the farmyards of their breeders, are free from worms which are likely to live in the body of man. The Irish pig is the one most commonly injured by *Entozoa*, and the reason for this is evident when we know how much the cottager relies on rearing a porker, which is permitted the free range of house and road, where every description of filth is devoured, charged with the ova of parasites expelled by man, or some of the lower animals. . . . . The conditions under which we live in the British isles are certainly much less favourable to the propagation of worms ; but we disregard, in our ignorance, the most common precautions to protect ourselves from loathsome diseases, and not only permit dogs to eat any kind of offal in and around slaughter-houses, but sanction the existence of piggeries, where all kinds of garbage charged with worms or their eggs are daily devoured by swine. The majority of germs calculated to engender parasites are to be found in abundance in the contents of the alimentary canal of human beings and domestic quadrupeds. If pigs are permitted to eat these, as in Ireland, or in many British piggeries, we must expect hams, bacon, and pork sausages to be charged with the embryonic forms of human *Entozoa*. Whereas in Iceland the dog is the victim of human negligence, and, *en revanche*, the cause of human disease, in the British isles the pig holds this unenviable position. The more, however, we learn of parasitic diseases in man, the better we can understand how even the underdone roast beef of Old England may prove to us poison as well as food, and how the dog or the cat we pet may indirectly shorten our days. We have good reason to believe, with Moses, that the pig is an unclean beast; but without discarding him from the scanty list of animals to be eaten, it is evident that we can purify the race of swine, and thus prevent human as well as porcine maladies." *Strongylus bronchialis* is the name given to the species described in the E. C. vol. ii. col. 576, as *Filaria bronchialis*, as it has been shown that the species so named is identical with *Strongylus longevaginatus*, and hence really belongs to the genus *Strongylus*. *Eustrongylus gigas* is the name by which the *Strongylus gigas* of the E. C. vol. ii. col. 577, is now known. *Sclerostoma duodenale* is a common parasite in Italy and Egypt. *Oxyuris vermicularis*, noticed in E. C. vol. ii. col. 578, as *Ascaris vermicularis*, is especially abundant in children, but it also occurs in persons of all ages. The Guinea worm, which is referred to in E. C. vol. ii. col. 576. as *Filaria medinensis*, is now denominated *Dracunculus medinensis*, but as yet only the female has been discovered, and she developes the young viviparously. From this circumstance we can understand in part why so much caution is required not to rupture the worm while extracting it. It ought also to induce practitioners to burn the worm, and not simply to throw it away, since the embryos are capable of retaining their vitality under very adverse circumstances, such as desiccation. It is during the rainy season that the Guinea worm is liable to be taken into the system, since the embryos swarm in all the places where water stagnates, such as ponds, wells, reservoirs, damp mould, and mud. The females appear to penetrate through the ducts of the skin, since it has been observed that it usually occurs in the legs and feet, which parts are frequently left bare by sailors in warm latitudes, and in the shoulders of the Indian water-carriers, who usually carry the water-skins on their backs. M. Guyon and the inhabitants of the countries where this parasite is most abundant believe that the worm is introduced by the alimentary canal. This, no doubt, may be the case in some instances, but not in all, nor probably most of them. *Dracunculus Loa* is a species found in the conjunctiva of negroes dwelling in the Congo and Gaboon districts, but it is also frequently met with in the West Indies and Brazil, where it may have been introduced from Africa by imported slaves.

There are a few species of internal parasites which do not belong to this class, but of these we need say nothing. Nor is there any occasion to allude to the spurious *Entozoa*. We may, however, notice that the *Spiroptera hominis* [E. C. vol. ii. col. 577] is not a human parasite. The species so named is the *Filaria piscium*, which naturally occurs in the haddock. The ova-like bodies which were passed by the poor woman of St. Sepulchre's Workhouse have been ascertained to be the eggs of some fish, probably of the haddock, and with these were associated fragments of the ovisac. There can be little doubt that these objects had been artificially introduced into the urinary canal for purposes of deception.

Sphærularia bombi is a remarkable entozoon which infests various species of *Bombus*, especially *B. terrestris*. In the youngest stage observed by Sir J. Lubbock, who has done more than any other individual to advance our knowledge respecting this species, the male was about $\frac{1}{30}$th of an inch in length, and the female somewhat shorter, or about $\frac{1}{40}$th of an inch. The full-grown male is very little larger, but the mature female is nearly an inch long, so that the inequality of the sexes is probably greater in this than in any other species of entozoon. Schneider's mode of grouping the genera of this order differs essentially from Cobbold's, and his 'Monographie der Nematoden' is the most important recent monograph upon the subject to which it relates. It may be useful to give his scheme :—

I. Polymiarii. Muscles of the body, consisting of numerous cells, arranged closely and one behind the other.

1. *Ascaris*, Rudolphi. Two symmetrical spicula; 20 and more preanal papillæ.
2. *Eustrongylus*, Diesing. A spiculum (?); bursa cup-shaped.
3. *Enoplus*, Dujardin. Two symmetrical spicula; bodies of both male and female with many papillæ; the papillæ of the tail of the male passing into the body papillæ.
4. *Physaloptera*, Rud. Two unsymmetrical spicula; bursa closed, heart-shaped, surrounding the apex of the tail; a single papilla for the anus; 10 papillæ, all constant.
5. *Heterakis*, Duj. Two unsymmetrical spicula; male with a sucking disk at the anus; 3 large preanal papillæ.
6. *Filaria*, Muller. Two symmetrical spicula; 4 preanal papillæ.
7. *Ancyracanthus*, Diesing. Two unsymmetrical spicula; 15, 16 or 20 preanal papillæ, singly or in pairs, arranged in rows.
8. *Hedruris*, Nitzsch. Two unsymmetrical spicula; 2 preanal papillæ.
9. *Ceratospira*, Schneider. Two unsymmetrical spicula; 11 (?) preanal papillæ.
10. *Cucullanus*, Mull. Two symmetrical spicula; 7 preanal papillæ.

II. Meromyarii. Muscles of the body, consisting of eight rows of cells, placed one behind the other.

11. *Nematoxys*, Schn. Two symmetrical spicula; male and female with many papillæ over the whole body; the tail papillæ of the male passing into the body papillæ; vagina with sphincter muscle.
12. *Oxysoma*, Schn. Two symmetrical spicula, 3 large constant preanal papillæ; vagina with sphincter.
13. *Oxyuris*, Rud. One spiculum; bursa present or absent; vagina with sphincter.
14. *Labiduris*, Schn. Two symmetrical spicula; tail papillæ of the male lengthened out into a kind of forceps.
15. *Dermatoxys*, Schn. No spiculum; bursa broad.
16. *Atractis*, Duj. Two unsymmetrical spicula; 3 preanal papillæ.
17. *Spiroxis*, Sch. (No characters are given.)
18. *Strongylus*, Rud. Two symmetrical spicula; bursa closed all round, forming a funnel; all the papillæ with costæ; the six anterior papillæ constant, the first single, the second and third forming a knot, the remainder single; vagina with long muscles.
19. *Pelodera*, Schn. Two symmetrical spicula; bursa always present, surrounding the extremity of the tail; 4 or 5 preanal papillæ.
20. *Leptodera*, Duj. Two symmetrical spicula; bursa wanting or not surrounding the extremity of the tail; 3 preanal papillæ.

III. Either no muscles, or when present, running in a longitudinal direction.

21. *Anguillula*, Ehr. Lateral bundles; a main median line; two symmetrical spicula; bursa broadened anteriorly, with a rounded edge, posteriorly obtuse.
22. *Trichina*, Owen. Lateral bundles; median line; no spiculum; bursa with a double knot.
23. *Trichosoma*, Rud. Lateral bundles and main median line (secondary?); a spiculum; sheath of the spiculum closed with a lid; bursa.
24. *Trichocephalus*, Göze. No lateral bundles; main median line; a spiculum; sheath of the spiculum closed with a lid; no bursa.
25. *Pseudalius*, Duj. Lateral bundles; all have main, and

some also have secondary median lines; two symmetrical spicula; bursa twice forked, spoon-shaped, or wanting; several papillæ.

26. *Ichthyonema*, Diesing. Lateral bundles; main median line; no anus; two unsymmetrical spicula; tail end of male truncate.

27. *Mermis*, Duj. Lateral bundles; main median line; secondary back lines; no bursa; two symmetrical spicula; bursa widened; 3 or 4 rows of papillæ before and behind the anus.

28. *Gordius*, Muller. No lateral bundles; no ventral line; no anus; no mouth (?); no spicula; bursa twice forked.

29. *Sphærularia*, Dufour. No characters are given. Schneider says it resembles no other Nematoid, and is evidently doubtful as to its really belonging to the order.

Before closing this article, we ought not to omit to mention that Diesing has contributed a series of memoirs to the 'Sitzungsberichte der Akademie Wissenschaften der Wien,' which bear principally upon the classification of the *Entozoa*. His arrangement is based upon purely artificial principles. The papers embody the results of an immense amount of research.

(T. S. Cobbold, *Entozoa*, 1864; R. Leuckart, *Die Menschlichen Parasiten*, vol. i. 1864; vol. ii. 1867.)

EOCENE [E. C. vol. ii. col. 578; and TERTIARY SYSTEM, E. C. vol. iv. col. 1044]. The name given to a period of past time, and to a series of stratified deposits which were accumulated during that period. The strata to which we allude occur in patches and streaks in the neighbourhood of London, in Hampshire, around Paris, in Belgium, Switzerland, Prussia, Austria, Italy, Turkey, India, the Philippine Islands, North America, and other localities. The beds are varied in composition, of considerable aggregate thickness, and in many places contain a profusion of organic relics, belonging to marine, lacustrine, and terrestrial species. They are the oldest deposits known belonging to the tertiary formation, and yet the creatures whose remains they inclose were almost entirely different, specifically, from those which flourished during the deposition of the latest formed secondary rocks hitherto detected. The eocene beds generally rest unevenly upon the strata beneath them, a phenomenon which geologists designate unconformability, and which they look upon as a manifestation that a period of time elapsed between the formation of the older and newer beds. What number of years this gap, or break in the continuity of sedimentary deposit, represents, there is no practical way of deciding, but one feels that it must be considerable from the great alteration which has taken place in the character of the fauna. When the stratigraphical distribution of the fossils of a series of beds, which do not present a high degree of unconformity amongst themselves, is studied, it is observable that the species seem to vanish and appear either singly or in small groups, especially when regard is had to strata representing nearly the same conditions. Concomitantly with this gradual change in the fauna is a blending of the beds of one character with those of another; so that the appearance of the clays is preceded by sands, limestones, &c., with more or less of argillaceous matter in them. But when we pass from the highest chalk to the lowest eocene beds all the old species have disappeared, and the newer beds rest irregularly upon older deposits. The sea areas of the secondary period were evidently very different in position, and form, and size from those of the oldest tertiary, for the eocene beds rest sometimes upon chalk, sometimes on the oolites, and sometimes on palæozoic strata. This contrariety of distribution and specific forms is not the result of some cataclysmic action, but is indicative of a thick series of beds which are not represented in the areas hitherto examined between the chalk and the eocene beds. These gaps generally mark the spots where the surface was subjected to subaerial conditions, and if such surfaces were not land they were subjected to the action of waves, and waves can only denude between wind and water. Hence, it may be said, that these gaps represent time; for if the intermediate beds were ever deposited they have been swept away again, an operation which involves time; and if they have not been deposited where we see the gaps then the boundaries of the old seas must have altered very considerably, which operation also implies time. Gaps of a similar character but of far less proportion occur between the subsidiary groups of the eocene series, but generally they can be correlated with intermediate deposits on another area. The fluctuation of the land and sea during the eocene period is well shown by those gaps as well as by a consideration of the oldest eocene beds of each district.

The eocene beds are generally arranged in three groups, termed respectively, the lower, middle, and upper eocene. The lower eocene beds are fully developed in the London basin, while those which form the upper eocene of Lyell are best displayed in Hampshire and the Isle of Wight.

In the London basin the lower eocene strata rest upon chalk, the surface of which is almost everywhere covered with a thin band of argillaceous greensand in which are a number of flints of a dark or green colour, and both unworn and uncorroded. It is very persistent, and indeed is the only bed which is conterminous with the basin. This bed does not seem to be a stratified deposit, but rather the result of the action of waters which have percolated through the superincumbent detritus to the chalk beneath, of which they have carried away the soluble parts and left the insoluble in place. A layer of analogous character, that is, one which consists of what may be the insoluble residue of chalk, is found wherever the chalk is covered by permeable deposits. It is a question what the age of this bed may be. Some think that it may represent the result of subaerial denuding agencies prior to the laying down of the superjacent tertiaries; but this view is not generally acquiesced in. Another, and the more probable, view is that the bed has been of gradual formation during and after the deposition of the overlying strata. Excluding this bed the oldest tertiaries in the London basin are the Thanet beds, whose composition is generally sandy, but not always, as the term Thanet sands usually applied to them induces one to suppose. At Pegwell bay the green-coated flints are succeeded by some bands of clay and loam, which thin out and are lost towards the west. It passes upwards into a sandy marl, which forms a conspicuous feature to the east of Canterbury, since it attains a thickness of forty or fifty or more feet. It is usually hard, of a slate-grey colour when fresh, but brownish-yellow when weathered, and, in places, abounds in fossils. It becomes more sandy towards the summit, and thins out rapidly towards the west, no trace of it being discoverable beyond Rochester. The next and uppermost bed, into which the last-mentioned passes, is a fine slightly greenish or light grey sand which is interstratified in places with bands of a calcareous sandstone. It contains a few fossils and, like the lower beds, thins out towards the west, and disappears short of Rochester. It will then be seen that the marls, sands, and loam, which form the Thanet beds east of Canterbury to a thickness of more than ninety feet, and which thin out towards the west, do not extend beyond Rochester; and yet Thanet beds are known much further west. This is explained by an intermediate bed which first commences near Canterbury between the sands and loam below and the sandy marl above. It is a fine buff sand, which first thickens in advancing westwards, ultimately replaces all the other beds, and then fades away again. Thus, near Canterbury it is but a few feet thick, near Sittingbourne it is thirty feet, while the other beds are about fifty feet thick; at Upnor it is sixty feet, and the other Thanet beds are entirely absent; at Woolwich it is about fifty feet; at Lewisham it is less than forty; beneath London it is about five and twenty feet; and it is entirely absent west of the metropolis.

The next series of strata are the Woolwich and Reading beds. These, like the preceding set, are heterogeneous in composition both vertically and horizontally. The lowest stratum (1) is not developed in the extreme east of Kent; but near Canterbury its proximity is indicated by the lower portion of the sands which there rest upon the Thanet beds being green, somewhat clayey, and slightly pebbly. Farther west the pebbly greensand becomes well defined as a distinct stratum, having a thickness of about a foot in the Rochester and Sittingbourne districts; still more to the west it thickens, and between Gravesend and London its vertical dimensions vary from three to upwards of fifteen feet. The thickness does not increase uniformly, changes occurring rapidly within short distances; but in the main the bed is more massive in the west than in the east. West of London it passes into a dark clayey greensand and into grey laminated clays with a few green grains. The next stratum (2) in ascending order appears in the easternmost portion of Kent as a fine sand which rests upon the Thanet sands, which it closely resembles in appearance. In advancing westwards it acquires a grey, or yellowish, or greenish tint, the grains become coarser, and the materials are much false bedded; which characters mark it off distinctly from the underlying Thanet sands. In more western areas, as beyond Canterbury, it is still more decisively separable from the Thanet sands by the interposition of the pebbly greensand already noticed, and by lithological mutations. These changes have not been rigorously settled; but are inferred from stratigraphical considerations. Thus, at Woolwich, the pebbly greensand supports sand; at Lewisham it supports a greenish pebbly loam; under or close to London a mottled clay occupies this position; and west of London this clay, which is more or less sandy in places immediately underlies the similar plastic clays, which will be again mentioned presently. Between Woolwich and London these variously constituted beds are overlain by the estuarine shelly deposits (4) which form a well-marked horizon across the country. In one or two places a thin bed (3) intervenes, which will next be adverted to. It consists, in the east, of a pale purple grey sand concreted in places into hard nodules, and is seldom more than three inches thick. Near Canterbury and at Shottenden Hill it is the uppermost of the Woolwich and Reading series. It is not seen near Sittingbourne, but at Upnor it appears to be represented by the sand, which is whitish above and purplish below, which comes in between the sands (2) and the shell beds (4). It does not occur at Plumstead Common where the lowermost only of the Woolwich beds is present, the remainder having apparently been denuded away. At Woolwich is a layer of hard concretionary limestone, which occupies the position of, and probably represents, this stratum; a remark which also applies to the clay with calcareous concretions at Lewisham. No trace of it has been recorded to the west of Lewisham. The shelly bed (4) commences in the east near Sittingbourne, and can be followed almost continuously, there being a break around Plumstead, as far as London, but beyond this it has not been discovered. It is composed of dark laminated clays, interstratified in places with sands, and is best developed near Chiselhurst, where its thickness is upwards of twenty feet. The uppermost bed (5) is not seen near or east of Canterbury. Near Sittingbourne it is a light-coloured sand, and is traceable for many miles to the west. It has been subjected to much denudation, and this may be the cause of its absence in east Kent. It is to be seen at Upnor, and near Gravesend, but is absent on Plumstead Common, owing no doubt to denudation, for it again appears near Woolwich with a highly eroded surface. At Lewisham the highest stratum of this series consists of alternations of clay and sand, but it is doubtful if it is the continuation of the Woolwich sands. Under London the place of this stratum (5) is occupied by plastic clays and sand, which are brought down (west of London) upon the plastic clays below the shell bed, by the disappearance of the intermediate deposits.

Between the Woolwich beds and the London clay is a series of strata which Mr. Whitaker has proposed should be grouped together as the Oldhaven beds. It consists of three beds. The lowermost (1) is to be seen at Upnor, where it occurs as a pale greenish-yellow shelly sand, distributed in patches owing to portions having been swept away. Next comes a sandy pebble bed (2), with fossils, which, however, is so inconstant in the nature of its material and the character of its fossils that it is not certain that all the pebbly beds in Kent which occupy this position are really referable to one continuous deposit. Near Canterbury it is thin, and in one place becomes a mass of sandy brown iron ore, 5 feet thick; at Shottenden Hill it is nearly 15 feet thick; near Sittingbourne and at Upnor it is again thin; along a district running from Erith on the north to Chiselhurst and Bromley on the south it is upwards of 20 feet thick; it then thins away rapidly towards the west, and near Lewisham is represented by a layer less than a foot thick, which is not now accessible to view. As an example of the change in the fossils it may be noticed that estuarine species, such as *Cyrena cuneiformis*, *C. cordata*, *Melania inquinata*, occur at a pit near Boughton-under-Blean; while a second, less than a mile distant, has a mixture of fresh-water shells with marine forms belonging to the genera *Cardium*, *Pectunculus*, *Aporrhais*, *Calyptræa*, and *Fusus*. The most remarkable feature about this bed is that the flints are black, and thoroughly well rolled. Scarcely any of the flints have angulated margins, such as occur in most pebble beds, as well as in almost every beach where pebbles are being rounded, and where the material presents every stage from the raw article to the finished production. Hence it would seem probable that the pebbles of the Oldhaven series were not rounded where we now find them, but that they were formed somewhere else, and were then transported under conditions which insured sufficient attrition to finish the rounding off of the stones, and prevented the influx of fresh unrolled flints. From these circumstances it might be suspected that these pebbles are re-derived from older tertiary beds—a surmise which is worth further investigation. Whitaker, however, remarks that they must have been derived directly from the chalk, since none of the older tertiaries would afford such an abundance of flints. This is true, but still it is just possible that they may have been derived from strata intermediate in age between the Thanet beds and the chalk.

Above the Woolwich beds follows the London clay, which is a tough brown and bluish grey clay, with septaria. We cannot here dilate upon its rich fauna, which is abundant in species and remarkable in its character, affording evidence as it does of land mammalia inhabiting the same district as large crocodilian reptiles, of palms and plants belonging to tribes which now flourish in warm regions, of marine mollusca appertaining to genera which, at the present day, thrive best in sub-tropical seas, and of genera of fishes now no longer to be found on British shores, but represented in more southern climes.

In the Isle of Wight the lowest eocene beds are poorly developed. The lowest bed, exposed in Alum Bay, is a brown sand resting on the eroded surface of the chalk. Above it follows a series of variegated clays, and the whole series is usually regarded as equivalent to the Woolwich and Reading beds, but as it has yielded no fossils, it is difficult to decide that the Thanet and Oldhaven beds are entirely unrepresented. The thickness of the series varies from 84 feet in Alum Bay to 163 feet in Whitecliff Bay. The London clay consists of a succession of dark blue clays and sands, with frequent layers of nodules of argillaceous ironstone.

The Bagshot and Bracklesham beds represent the middle eocene period in England. In the Isle of Wight the lower Bagshot beds acquire a considerable thickness, being rather more than 661 feet thick in Alum Bay. They consist of variegated sands and clays, amongst which are distributed several layers of ferruginous sandstone. The clays and sands differ from those of the London clay beneath by their lightness of tint. They are for the most part unfossiliferous, but in the upper portion of the series in Whitecliff Bay, and much nearer the base of it in Alum Bay, is a group of laminated pipeclays which abound in fragments of leaves. The plant remains of Alum Bay have been described by Messrs. De la Harpe and Salter, who have ascertained their identity as a flora with the plant remains found at Bournemouth and Corfe Castle, in Dorsetshire. Their remarks refer generally to the plants of the Hampshire basin, and relate to about 50 species, mostly referable to living genera. The investigation of this flora has been urged forward by the British Association; and we believe Mr. Mitchell will give the results in a volume to be published by the Palæontographical Society. The Bracklesham beds succeed the last-mentioned group, and in Alum Bay consist of clays and marls in the lower portion, and brightly coloured sands in the upper. Near the base are some bands of carbonaceous matter, indicative of a large quantity of vegetable matter. These bands are termed lignite, and vary in thickness from 9 inches to 2 feet 3 inches. They are so hard that they project beyond the softer clays and marls with which they are associated, have a dark coal or rather jet-like appearance, and, like true coal seams, rest upon an under clay in which the rootlets of plants can be detected. Similar beds occur at Whitecliff Bay, where they are more fully developed. There the lower part consists of lignite, clays, and green clayey sands. The highest stratum in Alum Bay is a hard bed of conglomerate, formed of rounded black flint pebbles, some nearly a foot in diameter; it is represented in Whitecliff Bay by a stratum 6 feet thick, through which pebbles of small size are dispersed. The Barton clay, which next succeeds, is well known on account of the profusion and variety of its marine fossils. The lower portion in Alum Bay consists of bluish green clays, and above the sands and clays are mostly of a yellowish tint. The entire group has a thickness of 300 feet. The Upper Bagshot sands are about 120 feet thick in Alum Bay, and consist partly of yellow and partly of fine white sands, which latter are extensively used in the manufacture of glass. Very few fossils are found in them.

A change now sets in. The fossils in the beds just noticed are almost exclusively marine; but in those which we have next to consider they are partly marine, largely fluviatile, and slightly terrestrial. They are grouped by Lyell as upper eocene; but the question of their nomenclature and equivalency with foreign deposits has latterly been eagerly discussed. Professor Forbes was the first to reduce the series to general order, to point out the true succession of the beds, and to correctly correlate those of Alum Bay and Whitecliff Bay with each other. Mr. Bristow recognises four groups of beds, named the Headon, Osborne (or St. Helen's), Bembridge, and Hempstead series. The lower Headon beds have a thickness of from 40 feet in Whitecliff Bay to 69 feet in Tolland Bay. They are chiefly of fresh or brackish water formation, as shown by their fossil contents. At Headon there are some limestones which thin out towards the west, and are replaced in Whitecliff Bay by clays and marls. The middle Headon beds also indicate by their fossils the prevalence of brackish water conditions in the western portion of the Isle of Wight, which are far less decidedly marked in Whitecliff Bay, where most of the species are marine. The upper Headon beds consist of clays and limestones, which contain a great many fresh-water shells. The Osborne series consists of red and green marls and clays; and, in places, of calcareous sandstones or concretionary limestones, which abound in remains of *Paludinæ* and other fresh-water genera. The Bembridge series comprises beds which have greater constancy in lithological character and fossil contents than those above and below it, and as they are generally distributed they form a well-marked horizon. The lower portion is usually calcareous, consisting of limestone, or of limestone beds separated by partings of marl and shales. The Bembridge limestone, as this part is called, is generally unfossiliferous, but in places it is very rich in shells. The upper portion consists of dark clays, and marls, and abounds in specimens of various species of *Cyrena*, *Melania*, *Paludina*, *Cerithium*, &c. It is sometimes designated the Bembridge marls. The Hempstead series consists chiefly of marls of fresh-water and estuarine origin in the lower portion, and dark-coloured tough clays in the higher. The highest of them are termed the *Corbula* beds, in consequence of their containing abundance of *Corbula pisum* and *C. vectensis*. Most of the species in them are marine.

Having thus very briefly, perhaps too briefly, summarised the general character of the strata, we will allude to the views of one or two geologists as to the foreign beds with which they correspond. Lyell correlates them as shown in the following table :—

UPPER EOCENE.

French sub-divisions.	English equivalents.
A. 1. Gypseous series of Montmartre.	1. Bembridge series.
A. 2. Calcaire silicieux or Travertin Inferieure.	2. Osborne and Headon series.
A. 3. Grès de Beauchamp or Sables Moyens.	3. White sand and clay of Barton cliff.
MIDDLE EOCENE.	
B. 1. Calcaire grossier.	1. Bagshot and Bracklesham beds.
B. 2. Soissonnais Sands, or Lits Coquilliers.	2. Wanting.
LOWER EOCENE.	
C. 1. Argile de Londres, at base of Hill of Cassel, near Dunkirk.	1. London clay.
C. 2. Argile plastique and lignite.	2. Woolwich and Reading series.
C. 3. Sables de Bracheux.	3. Thanet sands.

This grouping is objected to by Herr von Koenen, who considers that the Barton clay should terminate the eocene formation, and that the beds above should be separated into a distinct formation, to which he applies the name *Oligocene*, which would form a fourth period intermediate between the eocene and miocene. He divides it into the Lower, Middle, and Upper Oligocenes, all of which divisions are well displayed in Germany. His general views as to the correlation of some of the Hampshire (including Isle of Wight) strata, may be gathered from the following sentences :—"The lower oligocene is well developed, with a true marine fauna, in Belgium, near Tongres (north of Liege), and in the north of Germany, between Magdeburg, Bernberg, Aschersleben, Egeln, and Helmstadt (near Brunswick), and it contains about 700 species of mollusca, besides a large number of corals, bryozoa, and foraminifera, and several species of fish teeth and echinodermata; and the most characteristic of these fossils have also been found at Brockenhurst." He then enumerates 56 species, which have been obtained from Brockenhurst, and notices that of these "43 exist in the lower oligocene of Germany, and 6 are peculiar to the English Brockenhurst and Headon beds; 21 of them are found also in the upper eocene, and 4 pass over to the middle oligocene of Germany; 23 of these species are characteristic lower oligocene species, which have been met with neither in the older nor the younger beds, therefore there can be no doubt that the Brockenhurst beds, and with them the Headon series at Colwell Bay and Whitecliff Bay, belong to the lower oligocene. The middle oligocene occupies a very great surface of the continent; in France the 'Sables de Fontainebleau' are well known; and the Mayence basin is equally well so, through the excellent work of Professor Sandberger. M. de Koninck many years ago, and M. Nyst more recently, have described the fossils of the Rupelmonde clay of Belgium. The Rupelmonde clay, or clay with septaria, as it is called in Germany, is covered by the upper oligocene strata (yellow and green marls) round Cassel in Hesse, as Professor Beyrich has described in another paper read before the Royal Academy of Berlin. Proceeding eastward, we find numerous localities where middle oligocene beds occur, sometimes superposed to the lower oligocene, as in the neighbourhood of Brunswick, Magdeburg, Cöthen, Berlin, and Freienwalde in Mecklenburg, and, last of all, north of Stettin, where they consist of several hundred feet of yellow ferruginous sands, with occasional layers of dark 'Septarien-thon.' Generally the middle oligocene is developed as a dark bluish clay, possessing then a true marine fauna, identical with that of Rupelmonde (south of Antwerp), and containing *Leda Deshayesii*, *Fusus multisulcatus*, Nyst, and *Pleurotomæ*, as the most common fossils; this clay has always been considered as being the upper part of the middle oligocene, and is so in reality in Belgium, and generally in Germany. In the Mayence basin the Rupelmonde clay was discovered only a few years since by Mr. Weinkauff; and Professor Sandberger considers the marine sand of Weinheim, &c., as the lower part, and the clay with septaria as the upper part of the middle oligocene, including all the fresh-water beds in the upper oligocene. The marine sand of Weinheim he identifies with the 'Sables de Fontainebleau,' and some sandy beds at Neustadt-Magdeburg, and also with the upper (marine) beds of the Hempstead series. Now the fauna of the Neustadt-Magdeburg and Weinheim beds is somewhat different from that of the real 'clay with septaria,' described by several authors, but in certain localities in the north of Germany—for instance, near Söllingen (near Brunswick)—beds with the same fauna as those near Magdeburg are seen in superposition to the clay with *Leda Deshayesii*. We are obliged, therefore, to consider the difference of these two faunas as caused only by different conditions at the localities—difference in the depth of the sea, &c., indicated, too, by the difference of the lithological structure; and for this reason we cannot divide, generally, the middle oligocene into two periods." The introduction of a quadruple in place of a triple partition of the eocene formation has been largely adopted on the Continent; but it has not yet received general acceptance, since many geologists do not perceive the advantage, and would prefer to relegate the lower oligocene to the upper eocene, and the middle oligocene to the lower miocene, as has been done by Sir Charles Lyell in the 6th edition of his 'Elements of Geology.'

We have left ourselves no room to say anything about numerous other Eocene beds which occur on the Continent. Amongst these, perhaps, the most remarkable are those which constitute the nummulitic series, and which form part of the middle eocene. In the Alps, these beds are represented by immense thicknesses of sandstones and conglomerates, which are so poor in fossils that some have suggested they were formed during a cold period. This idea is probably of no value, for intense cold and poverty of life do not always go together. There are, however, some phenomena exhibited by these beds, which seem to indicate glacial conditions, such as large blocks of angular and rounded rocks, derived from neighbouring strata, and fragments of granite of unknown origin. Some of these granite blocks are between 10 and 100 feet across. They are not striated, nor polished, and indeed, present no direct evidences of glacial action; the only ground for supposing such action is that no other method will account satisfactorily for their distant separation from their parent source.

(E. Forbes, *On the Tertiary Fluviomarine formation in the Isle of Wight* (*Memoirs of the Geol. Survey of Great Britain*); H. W. Bristow, *Geology of the Isle of Wight* (*Mem. Geol. Survey of Great Britain*); Whitaker, *Quart. Journ. Geol. Soc.*, xxii., p. 404; Koenen, *Quart. Journ. Geol. Soc.*, xx., p. 97; xxii. (Part II.), p. 17; Lyell, *Principles of Geology*, vol. i.)

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FEATHERS [E. C. vol. i. cols. 464, 465]. These beautiful modifications of the excretory growths of the tegumentary system are, as Paley long ago observed, models of mechanical skill, in which great resisting strength is combined with extreme lightness. They present a greater variety of development than their representatives, the hairs, and scales of other vertebrates; many of them possess an exquisiteness of form and proportions comparable to some of the most delicate grasses; while the tints displayed by them are, perhaps, more vivid and varied than is met with in any other class than birds.

A feather in its fullest development consists of six or seven distinct parts. The main stalk of the feather comprises, first, a cylindrical portion, the *quill*, which is inserted in the skin, and the *shaft*, which is usually somewhat quadrilateral in form, and tapering in proportions. The quill is translucent and hollow. At its proximal end is an aperture, the *lower umbilicus;* and at the opposite, or distal end, is a second, the *upper umbilicus*, which open upon the groove on the under side of the shaft. The interior of the quill is partially occupied by a series of connected capsules, the lower end of which is attached to the base of the quill, and the other to the pith of the stem. A small process given off from one of these capsules proceeds to and through the upper umbilicus so as to close up this aperture. The diameter of the quill part of the stem is mainly uniform; but at the region where the shaft commences there is a gradual diminution. The shaft is grooved on the under, but round and smooth on the upper surface; and consists of a horny coating similar in nature to the quill, but more opaque, surrounding a white, elastic, pith-like interior. The shaft is slightly arched, and supports on either side a row of flat laminæ, or *barbs*, which are so arranged that their flat sides oppose each other, and their edges are directed, the one towards the upper or rounded and the other towards the under or grooved surfaces of the shaft. Their form tapers from their insertion in the shaft to their distal or free extremity. From their mode of arrangement it is manifest that they admit of movement readily in the direction of the length of the shaft, but with difficulty in that corresponding to its vertical diameter. The barbs vary in form, length, and thickness; and their upper margin is thicker than the lower. It is on each side of their upper margin that are situated the two rows of barbules, which, like the barb, vary in their several dimensions. In many cases the barbules on the side of a barb differ in form and in the character of the subsidiary parts from those on the other. Thus in the more firmly set feathers the barbules on the side nearest the distal end of the feather have an upward curve, and their downwardly directed extremities catch into those on the proximal side of the next barb, which have a downward curve and upwardly directed extremities. Barbules, however, are not restricted to this position, but may also occur on the main shaft. The barbules on the side of the barbs nearest the apex of the feather have a series of simple processes, *barbicels*, which are simple, filiform, and nearly straight; they also give off a series of somewhat similar processes, but they are far more curved, and terminate in hook-shaped points. By a peculiar arrangement of these *hooklets*, as they are termed, the barbules are firmly interlocked together. In addition to the parts already mentioned is another called the *accessory plume*, or *aftershaft*, which is a sort of second feather having a shaft and barbs, but which is generally much smaller than the main feather. It originates from the groove, and near the upper umbilicus. Its proportions and degree of development vary in the different groups of birds, and in some it is rudimentary.

The way in which the feather is developed is thus described by Professor Owen:—"The matrix or organ by which the perfect feather is produced, has the form of an elongated cylindrical cone, and consists of a capsule, a bulb, and intermediate membranes, which mould the secretion of the bulb into its appropriate form. The matrix is at first an extremely minute cone, attached by a filamentary process to a follicle or papilla of the skin; but it is not a development of that part, being of a different structure, and adhering by a small part only of its circumference. The matrix progressively increases in length, its base sinking deeply into the corium, and acquiring a more extended connection by enlarged vesicles and nerves, while its apex protrudes to a greater or less extent from the surface of the integument, when the capsule drops off to give passage to the feather which it incloses, and the formation of which has, in the meanwhile, been proceeding from the apex downward. The capsule of the matrix is composed of several layers, the outermost of which is of the nature of epiderm; the inner ones are more compact and pulpy. The sides of the capsule, which correspond to the outer and inner sides of the growing feathers within, are indicated by a white longitudinal line. The axis of the capsule is occupied by a medulla or bulb, also of a cylindrical form, and of a soft fibrous texture, adhering by its base to the parts beneath, and there receiving numerous blood-vessels and a nerve. Between the medulla and the capsule there are two parallel layers, one internal, the other external; from the latter membrane a number of close-set parallel laminæ extend obliquely from one of the white longitudinal lines above mentioned to the other on the opposite side of the cylinder. The two membranes seem to be united together by the oblique septa. In the long and narrow spaces between these septa the matter of the vane is deposited and formed into barbs and barbules. The deposition of the material of the barbs commences at the apex of the bulb, and the stem is next formed in the following manner. The external longitudinal line from which the oblique laminæ are continued, receives and moulds on the inner surface of the external capsule the horny covering of the back of the feather, or that longitudinal band to the two sides of which the barbs are attached; and on the opposite surface of the internal membrane are formed the pith or substance of the shaft, and the horny pellicle which incloses it on the inner surface. The internal longitudinal line has no other use than to establish a solution of continuity between the extremities of the barbs of one side and those of the other, which meet at that part, and thus curve round and completely inclose the formative bulb. The shaft and barbs at the apex of the cylinder are the first parts which acquire consistence, and the molecules which compose the remainder are less compactly aggregated as they are situated nearer the base of the matrix. As the gelatinous medulla increases at the base, the first-formed shaft and barbs are protruded through the extremity of the capsule, the bulb continuing to furnish the secretion which is moulded between the two striated membranes until the entire feather is completed. If the striated membrane inclosing the bulb be attempted to be reflected from below upward, it will be found to be connected with a series of membranous cones ranged one upon the other throughout the whole length of the bulb, and connected together by a tube running through its centre. As the development of the feather advances, the pulpy matter disappears from the summit of the medulla, and only the membranous funnel-shaped caps remain, which are protruded from the theca and the centre of the new-formed barbs, and fall off as these expand. The theca which incloses the whole is of a fine texture where the new-moulded barbs are yet pulpy and tender, but it becomes thinner as these acquire consistency, and, lastly, dries and crumbles away after it has been exposed to the action of the atmosphere. The bulb itself, when examined in a half-formed quill feather, is composed of two parts, corresponding to the external and internal aspects of the feather. The internal part represents a semicylinder or case, inclosing the external part, which is of a conical form; the latter expands from the base of the bulb and gradually diminishes to a point where the shaft is completed and the barbs begin to expand. Its office is to deposit the pith within the shaft, and it is absorbed in proportion as this is effected. The internal part or case also commences at the base of the bulb, and adheres closely to the cone, with which, indeed, its substance is continuous; it increases in thickness as the cone diminishes. Its margins are beautifully scolloped or crenate, and the crenations are lodged in the interspaces of the oblique laminæ or moulds, and deposit in them the material of the vane. The horny sides of the shaft are lodged and formed in the grooves between the external and internal parts of the bulb, and correspond in degree of formation to the depths of these grooves; and being progressively brought into contact from above, downwards, the shaft is thus completed, leaving the longitudinal line at the internal side. When all the grooves (wherein are formed the barbs, and the portion of the shaft which carries them) are filled by the horny matter, and the barbed part of the feather is finished, this horny matter lastly expands uniformly around the medulla, and forms the quill of the feather. When the quill of the feather has acquired the due consistence, the internal medulla becomes dried up, and is resolved, as before, into membranous cones arranged one upon the other; but these latter never pass out, for the quill, which is now hardened and closed by the shaft at the extremity opposite to the lower umbilicus, will not permit their egress; they remain, therefore, inclosed, and constitute the light dry pith which is found in the interior of the quill. The last remains of the bulb are seen in the ligament which passes from the pith through the lower opening of the quill and attaches it to the skin."

Feathers present various structures, are of different kinds, and are distributed in different ways. The principal structures are the *pennaceous*, the *downy*, and the *floplumous*. They are connected by intermediate links, and may occur in one and the same feather. In the pennaceous structure the shaft is strong, the barbs and barbules rigid, the barbules are compressed, and the anterior rows of these usually possess barbicels and hooklets. In the downy structure there is a general laxness of the parts, the quills being weak and short; the shaft and barbs soft and flexible; the barbules elongate, mobile, and filiform; and the hooklets absent. In the filoplumous structure the quill is thin and rigid; the shaft translucent and devoid of pith; the barbs delicate, rigid, and round; the barbules short, rigid, and filiform; and the hooklets absent.

Nitzsch recognises four kinds of feathers, which he terms *contour* or *surface-feathers*, *down-feathers*, *semiplumes*, and *filoplumes*. His description of them is thus rendered by Mr. Dallas in the English edition of the 'Pterylography,' issued by the Ray Society.

Contour-feathers may be the name given to the feathers furnished with a stiff and perfect stem, which, being exposed to the action of light on the surface, form the external outlines of the feathered body. The upper part, at least, of these vanes consists to a greater or less extent of barbs, and usually also of barbules of pennaceous structure, whilst the lower part, which is nearer the tube or quill, and concealed, has those parts usually downy, especially on the sides. The most perfect contour feathers, or those in which the pennaceous vane is largest and the downy part smallest, are the remiges of the wings and the rectrices of the tail. In the other contour feathers, which are often provided with an after-shaft, the great part usually belongs to the downy structure, and it is precisely in these that we find exhibited the greatest variety in the different families, genera, and species of birds, and also in birds of different ages, and even of different sexes. There are also contour feathers which are imperfect in various degrees. Thus, for example, some, which have the upper part pennaceous, have no barbicels and hooklets, such as those of the ostrich (*Struthio*) and nandu (*Rhea*); others have no barbicels on the pennaceous barbs, as in the two cassowaries (*Casuarius* and *Dromaius*). Nay, there are some contour feathers which are even destitute of barbs, either on the parts exposed to the light, as in the bristles of the angles of the mouth and of the chin and the eyelashes (in which, however, a sort of vane occurs at the lowest part), or throughout the whole shaft, as in the so-called wing spurs of the Indian cassowary, which I regard as feathers, although they possess no barbs, and depart from the regular form in other respects. These contour feathers are moved by numerous peculiar subcutaneous muscles. Some species of duck have as many as 3000 such feathers, and as each feather has four muscles, this would give an aggregate of 12,000 muscles. The *down-feathers* are recognised by the downy structure of all their parts: they are always found at a distance from the external outlines formed by the plumage, withdrawn from the light, and covered by contour feathers, or by the folded wings. They frequently stand between the contour feathers, namely, one in the midst of the space enclosed by four of the latter, so as to form, with them, a quincunx. This arrangement I have met with, especially in *Dysporus*, *Podoa*, and others. But we by no means always find a single down-feather between the four contour feathers, but frequently several of them, as, for example, in the *Unguirostres*, in which large and small ones occur together, and sometimes great numbers of them, as on the neck of the eagle. They are also found on spots which bear no contour-feathers, and constitute the external outlines of the plumage, as, for example, on the head and neck of certain vultures; but then the superior barbs possess compressed and nearly pennaceous barbicels, and thus form a transition towards contour-feathers. As regards their structure, down-feathers have either a simple shaft, or combined with this an after-shaft, where the contour-feathers are likewise furnished with the latter, as, for example, in the diurnal rapacious birds, the cranes, the herons, and others; or they are umbelliferous, in which case the shaft is entirely wanting, and the barbs are seated on the upper extremity of the tube, as, for example, in *Pelecanus*. The downy covering of newly hatched young birds consists, according to some authors, of down-feathers, and according to others, of hairs; in most birds, however, it is formed neither of one nor the other, but solely of early deciduous, down-like, or setiform processes, seated upon the apices of the first-formed barbs of contour-feathers or even of down-feathers. It it only in the *Unguirostres* that the nest-clothing consists of true down-feathers furnished with a shaft and tube. But these down-feathers are stiffer in all parts than the subsequent ones, and their barbules are remarkably thin. They exhibit no knots, or very small ones, and these bent alternately in different directions. The *semi-plumes* hold, as it were, a middle place between the down and contour-feathers, possessing the larger and more rigid stem of the latter, and the downy barbs and barbules of the former. They never stand, like the true down-feathers, between contour-feathers, but at the margins or extremities of the feather-tracts, where they complete the series of contour-feathers, or entirely take their place. They even form tracts without contour-feathers, where they stand closer together. They are, nevertheless, covered by contour-feathers, and withdrawn from the light. Frequently they have an after-shaft, when this also occurs in the contour-feathers; they are then distinguished from the neighbouring contour-feathers only by the want of the pennaceous apex. Others are more like down-feathers. They are larger in some storks, as, for example, in *Ciconia argala* and *C. marabu*, in which they are situated beneath the lower tail coverts, and are often employed as ornaments by our ladies: they also occur in the same situation in *Falco albicilla*. The *filo-plumes* are very strikingly distinguished from the other three kinds of feathers by their peculiar position, their extraordinary slenderness, and the entire deficiency or very small size of their vanes. At the same time, they are, as it were, associated with the contour-feathers, one, or even two, filo-plumes standing quite close to every contour-feather of the head, neck, and trunk, apparently issuing almost out of the same pouch of the skin. More rarely, as in the herons and *Unguirostres*, several filo-plumes (sometimes as many as ten) stand near each contour-feather. In their structure, they belong to the filamentous type, and no other occurs in them, except that sometimes, for example, in some gallinaceous birds, they have downy barbs and barbules at the base. The stem is usually so thin that it can scarcely be seen by the naked eye. In the cassowaries alone it is much thicker, and, contrary to the general rule, greatly compressed. It is, however, always rigid, straight, long, and filiform, and has a very short tube, scarcely distinguishable from the pithless shaft. This stem either emits no barbs, just like hair, or gives origin to a few barbs (frequently only one or two), and these always at the extremity of the naked shaft. These filo-plumes are probably common in all birds, at least I have never sought them in vain where I have taken the necessary trouble. Those standing very close to the contour-feathers are shorter, and entirely covered by them, but in most passerine birds, especially in *Fringilla*, *Sylvia*, and *Turdus*, some longer filo-plumes occur at the nape, and these project and pass beyond the apices of the neighbouring contour-feathers. In *Trichophorus* they even project a long way and curve downwards in the form of simple barbless hairs. Filo-plumes of a different and far more highly developed kind occur in *Halieus*, Illiger (*Carbo*, Meyer), in which they almost acquire the character of contour-feathers, for I believe that the delicate, white, downy-feathers which project on the neck from the otherwise metallic black plumage of this genus of bird must be regarded as filo-plumes, as, although they are furnished with perfect vanes, they agree both in position and in the slenderness of the stem and other parts with the feathers of this kind.

The contour-feathers are not usually distributed uniformly over the body, but are arranged in tracts or *pterylæ*. Their distribution is most complete in *Aptenodytes* and *Chauna*. The spaces which are not covered by contour feathers are termed *apteria*. Nitzsch recognises nine tracts, which are called respectively, the dorsal, humeral, femoral, ventral, neck, head, alar, crural, and caudal; and the spaces are distinguished as lateral neck, lateral trunk, inferior or ventral, spinal, upper wing, lower wing, crural, and head. Each of these is described in detail, and a special survey is given of the pterylosis of most of the avian genera, for which we must refer the reader to Nitzsch's work. (Owen, *On the Anatomy of Vertebrates*, vol. ii.; Nitzsch, *Pterylography*, translated by W. S. Dallas, edited by P. L. Sclater, and published by the Ray Society.)

FELIDÆ [E. C. vol. ii. col. 742-802]. In addition to the illustrations which have already been given in the E. C. of the remarkable adaptation of the structure of these highly typical carnivores for their mode of life, we would bring forward one or two more. Attention has been drawn (in col. 743) to the locking of the condyles of the lower jaw in the glenoid cavities, and to the conformation of those cavities being such that the lower jaw can only be moved vertically in the same plane, by which arrangement the teeth can lacerate and cut the food, but not bruise or triturate it. In the lion the temporal and masseter muscles are of large size, and each consists of two parts. The masseter has a horizontal and a vertical branch; the former weighing about eleven, and the latter about six and a half ounces. The temporal consists of a superficial and a larger more deeply seated layer. The horizontal branch of the masseter and the larger layer of the temporal are chiefly employed in closing the jaws; the smaller portions of each muscle co-operate in this act, but their more special function is to force the condyles of the lower jaw into their sockets. This modification of these muscles appears to be correlated with the habit which this beast has of carrying enormous weights for miles before eating it. The strain of an ox's body would dislocate the jaw were not special provision made for giving it firmness. There is another habit especially characteristic of the lion, and others of the cat tribe. It is that of crouching with the hind legs slightly separated and drawn up as far as possible, and of agitating the tail in a peculiar way immediately before making a spring. The principal muscles of the hind limb are the 'biceps femoris,' which exceeds all the others in size, the 'agitator caudæ,' and the three 'glutæi' named respectively 'maximus,' 'medius,' and 'minimus.' The relative sizes of the three 'glutæi' muscles are not the same as in man, in whom the 'maximus' muscle is much the largest. This is connected with his erect bipedal mode of progression. In the lion the 'medius' is by far the largest, being more than twice as heavy as both the others combined. This relation is associated with its mode of progression. Some of the muscles of the thigh extend the leg, others flex it, and others again have a rotatory action. In an adult lion dissected by Professor Haughton, the combined weight of the extensor muscles was nearly 91 ounces; of those which flex it 29 ounces; and of the rotators 51 ounces. Both the extensor and rotator groups are available for purposes of propulsion, and it will be observed how largely they exceed the other muscles. The bound, of course, will be greatest, according to the amount of the extension, and hence we perceive the advantage of the crouched-up position. The centre of action of these muscles is at the knee, and in order to their due action the patella requires to be duly adjusted. The 'agitator caudæ' extends from the side of the knee to the anterior caudal vertebræ, and it is this muscle which acts upon the patella. Hence there seems to be a relation between the vibratory undulating motion of the tail and the act of springing. Our space will not admit of citing more examples, although many could be given; but we may notice that this branch of our subject, the connection between special modifications of structure with special habits, does not receive that attention which its interest and importance deserve. For instance, what is the use of the so-called prickle in the lion's tail of which a woodcut is given in E. C. vol. ii. col. 753. Leydig has recently pointed out that it is not a sharp spine, but a sort of papilla or wart of complicated structure (analogous to that of a finger-tip), and richly endowed with nerves and blood vessels; and the presence of a minute horny nail increases the resemblance. It has all the appearance of being a delicate tactile organ, and possibly a minute study of the lion's habits might throw some light on the question. This peculiar structure is said to occur in the lion and puma only amongst *Felidæ;* but it is not unknown in other families. It is present in the aurochs only amongst ruminants; and is exceedingly well developed in *Macropus unguifer*, and *M. fraenatus.*

In E. C. vol. ii. cols. 749, 750, it is observed that the skulls of *Felidæ* have a great general resemblance, and that the main point of difference is that of size. In the article BEAR, E. C. S., a statement similar in effect is made. Dr. Gray, who has examined an immense collection of feline skulls, and indeed every anatomist who has given attention to the group, has been impressed with the same fact. There are differences, and perhaps no one has worked them out more carefully than Dr. Gray, who, as will be seen below, employs the differential characters of the skull in separating the genus *Felis* accepted by most authors, into fourteen. We imagine that too high a classificatory value is attached to these characters, but as Dr. Gray's synopsis gives a good idea of the nature of the dissimilarities, and is at the same time a useful summary of the forms at present known, we append a condensation of it.

Section 1. Normal cats. The flesh teeth of the upper jaw with a well marked prominent internal lobe on the front part of its inner side. The legs moderate.

Tribe I. True cats. FELINA.

The head oblong; face slightly produced. Legs moderate, nearly of equal length. The skull oblong; intermaxillæ and frontal bones with short processes, which extend between the ends of the nasal bone and the maxillæ. The front upper false grinder small (rarely deciduous and wanting).

A. Diurnal cats. The eyes diurnal, with a round pupil. The orbits of the skull moderate-sized compared with the size of the skull; face of the skull elongate, high, broad, flattened above.

* Forehead of skull suddenly elevated above the line of the face.

Genus 1. *Uncia.* Skull broad; face broad, short, flat above; forehead suddenly raised; crown convex in front and on the sides, concave behind; nasal bones broad, short, not reaching so far back as the upper edge of the maxillæ; upper processes of the intermaxillæ rather elongate, extending about one third up the sides of the nasals; orbits moderate, incomplete behind; canines conical, moderate; zygomatic arch very strong and high. The only species is *U. irbis*, which is the same as the *Felis uncia* of Schreber. It inhabits Tibet.

** Nose on the same plane as the forehead.

Genus 2. *Leo.* Head, neck, sides of body, and legs maned. Tail elongate, tufted at the end. Pupil round. Skull: nose on the same plane as the forehead; nasals flat, nearly as long as the maxillæ. The orbits of the skull moderate, incomplete behind. This also comprises but one species. *L. nobilis*, or the *Felis leo* of Linnæus.

Genus 3. *Tigris.* Cheeks with spreading whiskers. Tail elongate, tapering at the end. Pupil round. Skull: nose on the same plane as the forehead; orbits of the skull moderate, incomplete behind. Nasals very large, reaching beyond the back edge of the maxillæ. Internal nostrils broad. Palate truncated behind. It consists of *Tigris regalis*, or the *Felis tigris* of Linnæus.

Genus 4. *Leopardus.* Hair of head and neck uniform. Tail elongate (rarely shorter than the body). Pupil round; orbits of the skull moderate, incomplete behind. Nose on the same plane as the forehead. The upper process of the intermaxilla very narrow, and much produced up the side of the maxilla, often one-third the length of the nasal. It consists of six species, viz., *L. pardus*, which inhabits South Asia, and many parts of Africa; *L. japonensis*, a native of Japan; *L. chinensis*, of which a specimen has been obtained from near Pekin; *L. onca*, the jaguar of South America; *L. auratus* (*Felis auratus*, Temminck), which has been recorded from the Himalaya Mountains, Sumatra, and Borneo; *L. concolor* (*Felis concolor*, Linn.), the puma of North and South America.

Genus 5. *Neofelis.* Skull elongate; face broad, rather produced, on the same plane as the forehead. Nasal large, elongate. Orbit moderate, very incomplete behind. Lower jaw truncated, and high in front. Canine teeth, upper and lower, very long, conical, with a sharp cutting hinder edge; the front upper and lower false grinders distinct, early deciduous. The front lateral process of the frontal bone rather elongate. The hinder entrance to the nostrils very narrow, elongate; sides parallel; front edges rounded. Pupil round (Hodgson), oblong, erect (Bartlett). There are two species, *N. macrocelis* (*Felis macrocelis*, Temminck), which occurs in the Himalayas, Malacca, and Siam, and *N. brachyurus* (*Leopardus brachyurus*, Swinhoe).

B. Nocturnal cats. The pupil of the eye oblong or linear erect when contracted; the eye-ball large. The orbits of the skull large for the size of the face. The nose of the skull generally short, compressed above behind, with a more or less marked concavity in front of the orbits.

* Skull short and high.

Genus 6. *Pardalina.* Face round. Eye moderate, pupil (?). Skull short, high; face short; forehead arched in front; brain case swollen, short; orbits moderate, incomplete behind. First upper false grinder small; canines conical, moderate. Hinder aperture to the nose truncated in front. The only species is *P. warwickii* (*Felis himalayanus*, Warwick).

Genus 7. *Catolynx.* Head round; ears rounded. Pupil oblong erect. Tail very long, cylindrical. Skull ovate; face short, rather broad; nose slightly flattened on the sides; forehead arched; the nose bones moderate, elongate, separated from the maxillæ by the long, slender processes of the intermaxillæ and frontal bones. First upper false grinder small, distinct. Orbits large, sub-circular, complete or nearly complete behind. Internal nostril narrow, arched in front. There are two species, viz., *C. marmoratus* (*Felis marmoratus*, Martin), a native of India and Borneo; and *C. Charltoni* (*Felis Charltoni*, Gray), from Nepal and Darjeeling.

** Skull elongate; face and brain-case elongate.

Genus 8. *Viverriceps.* Head rather elongate. Ears rounded, not pencilled. Eyes nocturnal; pupil erect, linear. Fur spotted. Tail moderate, tapering. Skull elongate; face produced, narrow above, concave on the sides in front of the orbits; orbits rather large, complete behind; nasal bones elongate, very narrow above. Canines conical, moderate. Four species are enumerated. *V. Bennettii* (*Felis viverrina*, Bennett), of the East Indies; *V. planiceps* (*Felis planiceps*, Vigors and Horsfield), of Malacca, Sumatra, and Borneo; *V. Ellioti* (*Leopardus Ellioti*, Gray), of Madras; and *V. rubiginosa* (*Felis rubiginosa*, Geoffroy), also of Madras.

Genus 9. *Pajeros.* Head elongate. Ears rounded. Pupil round (?). Skull elongate and swollen behind; face short, broad; orbits moderate, incomplete behind. The front upper false grinder very early deciduous, always wanting in the half-grown skull. There is but one species, *P. pampanus* (*Felis pajeros*, Desmarest), the pampas cat of South America.

*** Skull ovate; face short; brain-case moderate.

Genus 10. *Felis.* Tail cylindrical, elongate, sometimes shorter than the body. Ears oblong, rounded at the tip without any pencilling. Pupil erect, linear. Skull moderate; face short, conical; nose moderate, narrow above behind, concave in front of the orbits; brain-case oblong, broad; front upper false grinders distinct, small; orbits large, or very large, incomplete. This embraces 29 species, named as follows. *F. pardalis*, Central America; *F. grisea*, Guatemala; *F. melanura*, America; *F. picta*, Central America; *F. macroura*, Brazil; *F. mitis*, Paraguay; *F. tigrina*, South America; *F. Geoffroyii*, South America; *F. collocolla*, Chili and Surinam; *F. jaguarondi*, South America; *F. eyra*, Tropical America; *F. serval*, South and West Africa; *F. rutila*, Sierra Leone; *F. neglecta*, Gambia; *F. celidogaster*, Guinea; *F. senegalensis*, Senegal; *F. caffra*, South Africa; *F. inconspicua*, India; *F. minuta*, Sumatra; *F. pardochroa*, Nepal; *F. chinensis*, China; *F. Jerdonii*, India; *F. javanensis*, Java; *F. nepalensis*, India; *F. maniculata*, North Africa; *F. catus*, Europe; *F. domestica*, probably an inhabitant of Syria, from whence it has been introduced into other countries; *F. manul*, Tibet; and *F. megalotis*, Timor.

Genus 11. *Chaus.* Tail shorter than the body, reaching to the hocks. Ears pencilled at the tip. Pupil oblong, erect. Skull: orbits very large, incomplete behind; nasal bones narrow, close on the maxilla; front upper false grinder distinct; upper tubercular grinder small, transverse; the lobe on the inner side of the upper flesh tooth moderate. The two species are *C. libycus* and *C. ornatus*, the former occurring in Africa and Asia, and the latter in India only.

Tribe II. Lynxes. *Lyncina.*

Head short, sub-globular. Legs elongate, the hinder ones longest. Tail short, or very short. Ears pencilled at the tip. Pupils of eyes oblong. The face of the skull short; the lateral processes of the intermaxillæ and the frontal bones elongate, nearly reaching each other, and separating the nasals from the maxillæ. The orbits incomplete, large; the lobes on the inner side of the upper flesh tooth moderate sized.

Genus 12. *Lyncus.* Tail very short. Limbs elongate. There are 8 species: *L. borealis*, North Europe and Asia; *L. lupulinus*, Sweden; *L. canadensis*, North America; *L. pardinus*, South Europe and Turkey; *L. isabellinus*, Tibet; *L. fasciata*, west side of North America; *L. rufus*, North America; *L. maculatus*, Mexico and California.

Genus 13. *Caracal.* Tail cylindrical, reaching to the hocks. Limbs more equal. Pads of feet bald. Pupil oblong. The skull is that of the lynx; but the processes of the frontals and intermaxillæ are not quite so much produced, and they do not entirely separate the nasals from the maxillæ. The front upper false grinder is absent. The orbits are rather large, and incomplete behind. The lobe on the inner side of the flesh tooth small. The single species, *C. melanotis*, occurs in the southern parts of Asia and Africa.

Section 2. Abnormal or dog-like cats. The flesh tooth of the upper jaw compressed, without any lobe, and only with a very slightly marked keel on the front part of the inner side. The legs elongate, slender.

Tribe III. Hunting Leopards. *Guepardina.*

Head short, subglobular; face very short, neck slightly maned. Legs elongate, slender, subequal. Tail elongate. Ears rounded. Pupil round (?) Skull: face very short, convex; the processes of the frontals and intermaxillæ very short, not separating the nasals from the maxillæ; the flesh tooth of the upper jaw compressed, without any lobe, but with only a very slightly marked keel on the front part of the inner side; the front upper false grinder distinct, small; orbits incomplete, moderate.

Genus 14. *Gueparda.* There is but one species, *G. guttata* (*Felis guttata*, Hern; *Felis jubata*, Schreber). It is a native of Africa and Asia.

(Haughton, *Proc. Roy. Irish Academy*, ix., p. 85; Leydig, *Annals of Natural History*, third series. vii., p. 278; J. E. Gray, *Proc. Zool. Soc.* for 1867, p. 258.)

FORAMINIFERA [E. C. vol. ii. cols. 867—874]. The researches of Messrs. Ehrenberg, Perty, Gervais, Williamson, Carter, Carpenter, and others, on these animals have led to the establishment of much clearer views as to the internal structure of the shells, the form of the soft parts, and the most natural method of classifying them. Until recently more importance was attached to the form of the shell than to its plan of structure, and the consequence has been that in several cases individuals of the same species have been arranged under genera supposed to be widely separated. D'Orbigny's method of classification has consequently been superseded by another one, an outline of which will be given presently.

The *Foraminifera* belong to the order *Reticulosa*, which with *Lobosa* and *Radiolaria* form the class *Rhizopoda*. They differ from both these orders in several respects. In *Lobosa*, of which *Amœba* is the typical form, [AMŒBA, E. C. S.], the pseudopodia are distinct, short, and broad. In *Radiolaria*, of which the typical form is *Actinophrys* [ACTINOPHRYS, E. C. S.], they are long, tapering, and distinct. But in *Reticulosa* they are long, of semi-fluid consistency, indefinite in shape, size, and number, and exceedingly ready to coalesce whenever they come in contact; they form a complex series of ramifications which has some resemblance to network, and from this circumstance the name of the order is derived. These processes have no well-defined margins, but their substance is in constant motion. The granules imbedded in the general protoplasm of which they are composed rapidly course along the whole length of the pseudopodia, and frequently from one pseudopodium to another by the cross connecting lines. As has been pointed out by Schultze ('An. Nat. Hist. 1861'), these phenomena are analogous to the circulation of vegetable cells in the protoplasmic substance of the hairs of *Tradescantia.* So great is the resemblance that Dr. Carpenter suggests that both may be caused by the same agency, namely, "a sort of peristaltic contraction in the threads of protoplasm." The bodies of these Rhizopods are far more homogeneous and structureless than *Amœba.* The inner portion is somewhat less consistent than the outer; but beyond this there is no distinction into *ectosarc* and *endosarc* as in *Amœba* [AMŒBA, E. C. S.]. Neither *nucleus* nor *contractile vesicle* have as yet been discovered in any members of this group, the majority of which have calcareous shells. These form the *Foraminifera;* such as do not possess shells are provisionally separated under the name of *Gromida.*

The calcareous forms will perhaps be better understood if we dwell upon those which do not have shells first. The genus *Lieberkühnia* presents a good example for illustrating the essential features of this group of animals. There is only one species, and this has been found in but one locality, near Berlin. Its body is about $\frac{1}{400}$th of an inch in length and consists of a homogeneous liquid holding a large number of *vacuoles* or clear spaces. From one end of the body issues a stem which ramifies into branches of extreme minuteness and great length; the branches are united by cross threads, so that the whole forms a complicated web of a viscous fluid-like substance several times longer than the body of the animal. All the threads circulate, as may be seen by the motions of the granules. When small particles of food come in contact with the pseudopodia they adhere, and move along with the general current until they reach the body. When large objects are caught, the weight or activity of which might tear away the network, a number of threads coalesce together to form an enveloping sheath round them, and both object and sheath are drawn in together towards the body. The *Actinophrys* secures large objects by a similar process [ACTINOPHRYS, E. C. S.] The granules from whose motion the circulation of the substance of the *pseudopodia* is detected, are of extraneous origin; many of them are particles of chlorophyll derived from the vegetable organisms that form part of the food of this creature. The granules circulate through the whole animal. They pass from the interior of the body to the extremities of the pseudopodia, and back again. The pseudopodia are best displayed, and the currents are most active, in the dark: or rather they are seen best immediately after the animal has been brought out of darkness. From the absence of any differentiation of parts it may be concluded that *Lieberkühnia* is far less highly organised than the *Amœba*, which is sometimes regarded as the simplest form of animal life.

In *Gromia* we have a higher stage. Its sarcode body is very nearly the same as that of *Lieberkühnia*, but is inclosed in a membranous test, with an aperture at one end through which the stem supporting the ramifying pseudopodia is protruded, as seen in *fig.* 1. The processes coalesce into knots and sometimes into thin layers of considerable area. From these centres pseudopodia are given off as from the body itself. The sarcode which protrudes beyond the mouth of the shell forms a thin layer outside the shell. From the hinder portion a few processes are given off, probably used for fixing the animal. Most of the *Foraminifera* attach themselves to various objects by means of their pseudopodia. The food is captured in the same way as in *Lieberkühnia*. In *fig.* 1 a Diatom is seen entangled amongst the pseudopodia, and the skeletons of others are just perceptible inside the test. In *Gromia* there is a circulation of granules similar to that in *Lieberkühnia*. Where the processes are mere filaments the current cannot be detected flowing in more than one direction. A granule, however, frequently goes to the extremity, turns back, and in advancing towards the body carries back a granule proceeding in the opposite direction. In the thicker pseudopodia two streams may frequently be seen, one going from, and the other towards the body. A granule passing along the edge of one of these may sometimes be seen to suddenly stop, to waver for a moment, and ultimately to join the other current. This phenomenon is of frequent occurrence in the circulation of such plants as *Chara*. The test of *Gromia* has been chemically examined by Schultze. It much resembles cellulose in its behaviour, but differs from cellulose in not being dissolved by sulphuric acid; it is apparently nearly allied to *chitine*, and some kinds of horn.

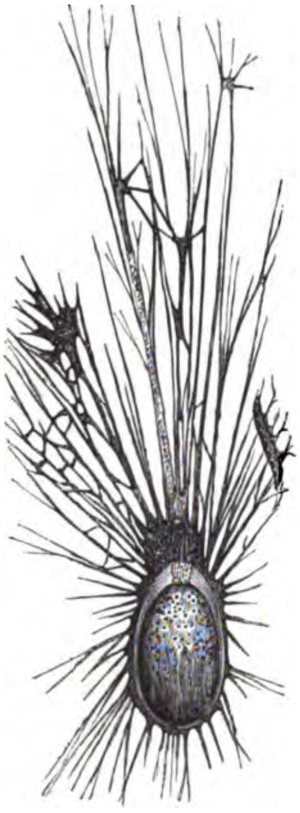

Fig. 1. *Gromia oviformis*.

The next group to which we would draw attention forms the family *Miliolidæ*. We can only notice here such of the principal forms as will suffice to give a general notion of the variety of shapes they assume, and the plan upon which their shells grow. By this way of treating the subject an impression is naturally given that all the forms to which distinct names are assigned are readily distinguishable from each other by certain well defined characters. This, however, is not so. The greatest difficulty is experienced in clearly defining any of the species as ordinarily accepted, especially when hundreds of individuals having the same general characters are brought together. Therefore, when in this article specific names are applied to any of the *Foraminifera*, it is for the convenience of specifying the varietal form it is wished to refer to. In consequence of the typical forms being connected by osculant varieties, it is frequently impracticable even to define a genus. This is the opinion of Dr. Carpenter and other persons who have studied large collections of *Foraminifera*. Dr. Carpenter has the following remarks on this point: "For whether or not there really exist in this group [the *Foraminifera*] generic assemblages capable of being strictly limited by well marked boundaries, it may be affirmed with certainty that among the forms of which such assemblages are composed, it is the exception, not the rule, to find one which is so isolated from the rest by any constant and definite peculiarity, as to have the least claim to rank as a *natural* species. Nothing is more easy, however, than to make *artificial* species in this group, for the variation to which every one of its generic forms is liable, gives rise to a multitude of dissimilar forms most inviting to those systematists who consider that credit is to be gained by adding new names to the already enormous list; and, accordingly, we find that a vast mass of such specific names and definitions has been accumulated, of which but a very few really express the facts they are designed to record. For it is the habit of such systematists to pick out only what they consider the well-characterised types, and to disregard the intermediate or osculant forms that establish the gradation between these, neglecting altogether the fact that the existence of such a gradational series entirely does away with the fundamental assumption on which the idea of a natural species (as ordinarily understood) is based. When a large collection of individuals of one generic type is brought together (such as that placed in my hands by Mr. Cuming of the *Operculina* of the Philippine Seas), it very commonly happens that by selecting the most divergent forms, a considerable number of specific types, say, six, eight, twelve, or even twenty, might be readily established, and a considerable part of the collection might be arranged around these as centres; but after all the specimens have been thus separated, which present a sufficiently close conformity to those types to admit of being referred to one or other of them without hesitation, there will remain a considerable proportion in which the characters of two or more are combined with such equality as to render it impossible to assign to them any other than an intermediate position; whilst there will be others which present such departures from any of them, as themselves to have an equal claim to rank as distinct species; so that there is no middle course between that of grouping the whole series as varieties of one species, and that of erecting into a distinct species every varietal modification presented by individuals, a course which would be the *reductio ad absurdum* of the ordinary system of species-making in its application to this group."

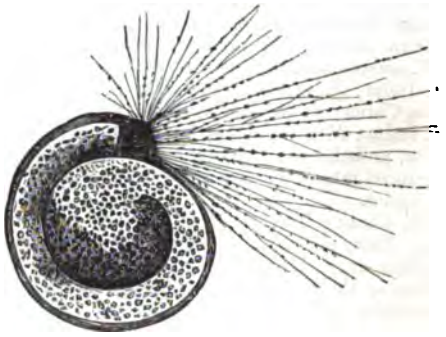

Fig. 2. A young *Miliola*.

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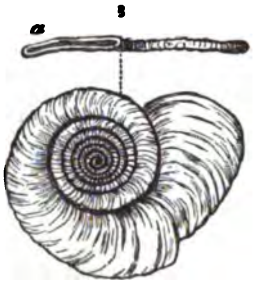

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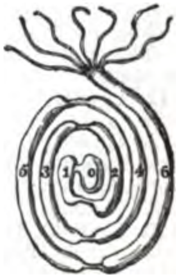
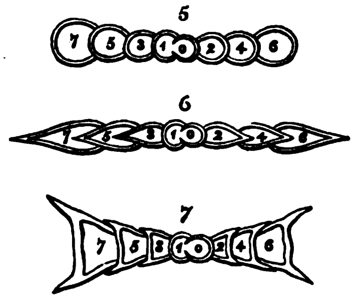


Fig. 3, *Cornuspira foliacea*.
Fig. 4. Diagrammatic sketch of the soft parts of *Miliola*.

In illustrating the Milioline type the genus *Squamulina*, or the young of *Miliola*, *fig.* 2, forms a convenient starting point. The former is a one chambered or *unilocular* shell, with a single aperture, through which the pseudopodia are extended. It is of an irregular lenticular form, much resembling that of the earliest or *primordial segment*, from which all the segmented *Foraminifera* are developed. In the young *Miliola* there is a central globular mass, from which proceeds a curved portion bearing the pseudopodia at its extremity. This presents great analogy to the central portions of many of the more complicated forms, such as shown in *fig.* 17. In *Cornuspira*, *fig.* 3, we have a simple continuous spiral, much resembling that of a *Planorbis*. There are no traces of septal bands or constrictions, if we except the slight depression which marks the point where the spiral part springs from the primordial chamber. The sarcode body presents a similar form. By a slight alteration we get the form of a *Miliola*, a diagrammatic sketch of the form of the soft parts of which is given in *fig.* 4. Commencing with the primordial segment *o*, we pass by a slight constriction, or *stolon*, to the first longitudinal segment, and so on by other constrictions to the segments numbered 3, 4, 5, and 6. The pseudopodia are placed at the *anterior* end of the last or *ultimate* segment. During the growth of the individual the pseudopodia always occupy the same relative position, and, consequently, they alternately occupy the two extremities of the shell. Each segment is always larger than the one previously formed. The principal source of the variety of the forms of species of the Milioline type is the variation in the shape of the longitudinal segments.



Figs. 5, 6, 7. Transverse sections of *Spiroloculina.*

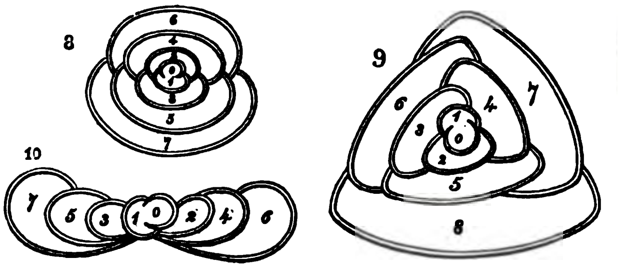


Fig. 8. Transverse section of *Biloculina.* Fig. 9. Ideal transverse view of *Triloculina.* Fig. 10. Ideal transverse section of *Quinqueloculina.*

In *Spiroloculina* the segments are curvilinear, as indicated by the soft parts in *fig.* 4. Another source of variation is the degree to which the segments overlap each other. If the segments approach a semicircular form the resulting shell is short and round, but if the segments are arcs of large circles it becomes elongated.

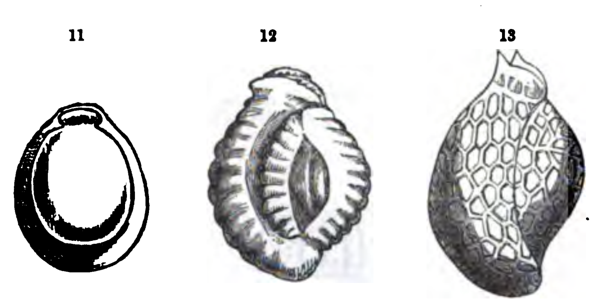


Fig. 11. Front view of *Biloculina.* Fig. 12. Lateral view of *Quinqueloculina.* Fig. 13. Lateral view of *Triloculina.*

Fig. 5 is an ideal transverse section of a *Spiroloculina*, in which the form of the chambers, and, therefore, of the sarcode, or soft part, is cylindrical; but this form may be either as represented in *fig.* 6 or *fig.* 7. The segments may be arranged round one another, as in *Biloculina*, *figs.* 8 and 11, *Quinqueloculina*, *figs.* 10 and 12, or *Triloculina*, *figs.* 9 and 13. These forms are readily distinguishable from each other when the marked varieties are considered, but they are all connected by intermediate varieties, so that none can be regarded as offering characters sufficiently constant to give them a claim to rank as genera. The apertures present as much diversity of form as the chambers. The surface markings of the shells frequently appear to be characteristic of specific forms; thus, in some the shell is smooth and highly polished, in others it is marked by a honey-comb pattern, by longitudinal or transverse ridges, or by minute pits. But none of these characters are of much value to the systematist, since in large series of specimens there is a gradual insensible transition from the smoothest to the most marked individuals. In *Fabularia*, *figs.* 14, 15, the plan of growth is distinctly biloculine, but the genus differs from *Biloculina*, in the cavities of the chambers being filled up with solid shell substance, and in the sarcode being lodged in long channels which pierce the solid parts generally in a longitudinal direction, but sometimes also in an oblique one.

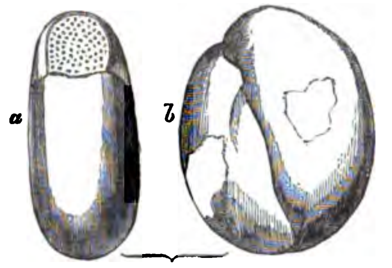


Fig. 14. *a*, end view: *b*, lateral view of *Fabularia.*

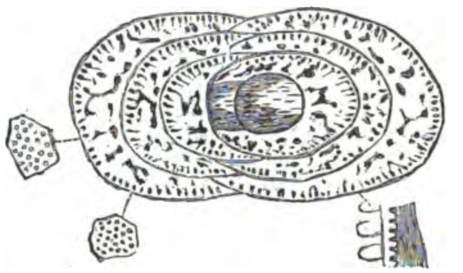


Fig 15. Transverse section of *Fabularia.*

All these forms illustrate various phases of the simple spiral mode of growth of the Milioline type; we will next notice the *cyclical* plan. In *Nubecularia* and *Vertebralina* the spiral plan usually prevails, but some varieties assume the cyclical. In this respect they foreshadow, as it were, the more

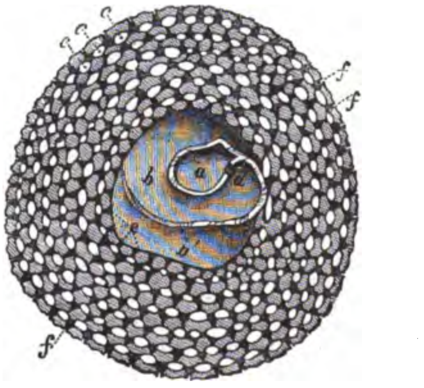


Fig. 16. Diagrammatic representation of *Orbitolites* of simple type; *a*, primordial chamber; *b*, circumambient chamber; *b*, portion of same partially separated by an incomplete partition; *c*, chamberlets of the concentric annuli; *d*, passage from the primordial to the circumambient chamber; *e*, passage from the circumambient chamber to the chamberlets of the first annulus; *f*, passage from gallery of last annulus opening at the margin of the disk.

complicated structure of *Orbiculina*, *Alveolina*, *Orbitolites*, &c. *Orbitolites* may be considered as the typical form of the group. It presents two kinds of structure, the *simple* and the *complex*.

When a shell on the simple type is bisected horizontally, as in the diagrammatic section *fig.* 16, the following parts can be detected; a *primordial chamber a*, surrounded by a *circumambient chamber b*, with which it communicates by an aperture, *d*, in the partition which encircles the inner chamber, and partially divides the outer one. These parts form the *primitive disk* which is connected by radial passages *e e* with the innermost rings of chambers *c c*. These chambers are also connected laterally by *annular galleries*, *figs.* 17 and 18, *h*, so as to form a connected zone. This zone communicates with the next outermost one by other radial passages, which usually extend from the inner annular gallery to the outer chamber, and hence the chambers of one zone alternate in position with those of the next. In this way a series of concentric zones are formed, each an exact repetition of the others with the exception that the number of chambers increases with each additional zone. The chambers in the outer are usually somewhat larger than those in the inner zone. The increase in the number of chambers is effected in the way shown in *fig.* 18 where three chambers occur below and five above; two having been interpolated in the third row. The apertures of the radial passages form the pores, *f f*, *figs.* 16 and 19, at the edges of the calcareous disks. The shelly partitions separating the chambers are single, not double, as is the case in some other types of *Foraminifera*. The pseudopodia are extended from the outermost portion of the exterior radiating pedicles. These perform all the work of catching food and introducing it into the sarcode. In consequence of the small size of the pores only the minutest plants and animals can serve as nourishment. There is no doubt that particles are introduced through the pores, since the interior of large shells are always found to contain numerous remnants of minute *Diatomaceæ*, *Desmidiæ*, &c. The particles thus taken in at the exterior of the sarcode serve to nourish the whole animal, which consists of a uniform homogeneous connected mass. As the creature increases in size the sarcode gets too small for its habitation, and a fresh zone of chambers is required. How the new layer of shell is formed has not been ascertained, but Dr. Carpenter suggests the following mode as probable. "The sarcode body of the animal, growing at the expense of the nutriment thus appropriated, will gradually, it is probable, project itself through the marginal orifices, not merely in filamentous pseudopodia, but in quantity sufficient to form a new zone; and it is easy to understand, from the analogy of other *Foraminifera*, that such extensions will coalesce with each other laterally, so as to form a complete *annulus* around the entire periphery of the disk. This at any rate, must be the case when a new zone is to be added to the shell; and it would seem as if this annulus then undergoes a thickening into segments by the accumulation of sarcode at the points at which it receives the radiating pedicles from the last zone of the sarcode body included within the shell, while it becomes narrowed in the intervening portions which form the connecting bands between the segments. It may be presumed to be by a calcareous exudation from the surface of the beaded ring of sarcode that the formation of the new shelly zone is accomplished; and if the calcifying process commence on the segments, and extend from these along the surface of their connecting stolons, we can understand why the passages that are left for communication with the exterior should arise from the intermediate divisions of the annular canal rather than from the segments themselves." The homogeneity of the sarcode of *Orbitolites* presents a remarkable contrast with the evident differentiation of the soft parts of the *Polyzoa*, with which Ehrenberg classes the genus. There is also a marked difference in their behaviour when immersed in spirits of wine. Thus, when a living *Orbitolites* is so treated the sarcode contracts and forms a single mass in the centre of the shell; clearly indicating that the sarcode is not attached to the walls of the cavities it occupies, and that it has a degree of plasticity that will enable it to be drawn through the narrow passages, and to coalesce without showing traces of having been spun out. As far as our knowledge goes, sarcode is the only animal substance that possesses this property. When a Polyzoon is similarly treated there is no contraction towards a common centre, but each zooid shrinks to the bottom of its own cell.

Some *Orbitolites* have a more complex type of structure; in most cases they are larger than those of a simple type, but there is no reason for supposing that the simple type is indicative of immaturity of the individuals. The largest *Orbitolites* occur in the Australian Seas, and sometimes have a diameter of ·5, ·6, or even ·7 inch. The disks of the complex type closely resemble those of the simple type as far as the central portion is concerned; but in the outer zones the shell is divided into three layers, two of which are superficial, and the third is intermediate, as seen in *figs.* 20, 21. The superficial layers are formed of oblong chambers having an aperture *i i* at each end of the floor, leading in a downward direction. There are no lateral commu-

17 18

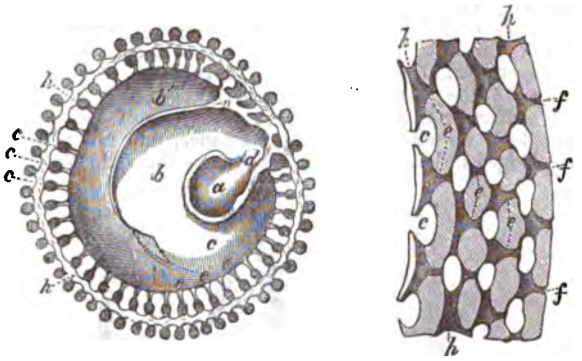


Fig. 17. Central portion of the sarcode body of *Orbitolites*; *a*, primordial segment; *b b*, circumambient segment; *c*, segment of first annulus; *d*, peduncle connecting primordial with circumambient segment; *e*, peduncles connecting circumambient segment with first annular. Fig 18. is an enlarged portion of Fig. 16, which shows the mode of connection of the chamberlets, *c*, by annular galleries, *h*, from which course off radiating passages, *e e*, leading to the zones.

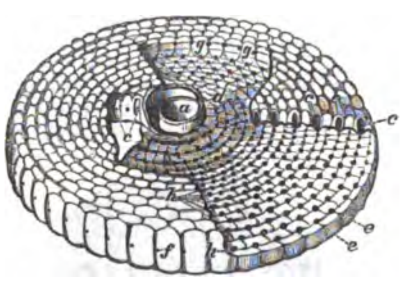


Fig. 19. Ideal representation of the disk of a simple type of *Orbitolites*. The lettering has the same significance as in previous figures.

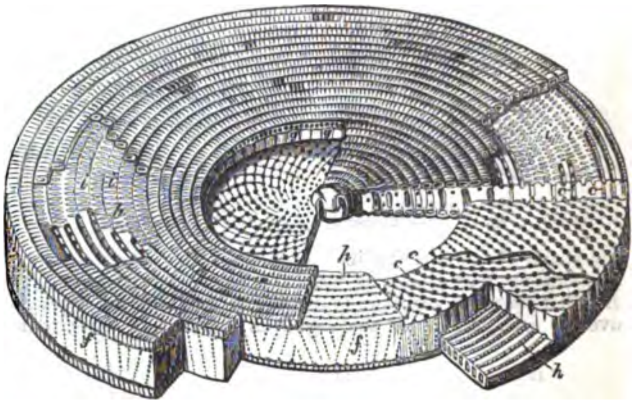


Fig. 20. Ideal representation of disk of complex type of *Orbitolites*. *f*, pores; *i*, superficial chamberlets; *h*, annular galleries: *c*, cylindrical chamberlets of intermediate zone.

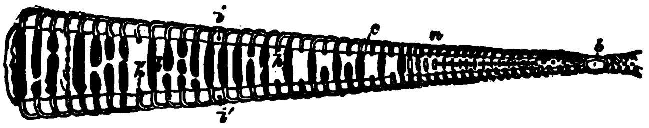


Fig. 21. Vertical section of complex disk; *b*, the principal chamber; *n*, indicates where the galleries become duplicated; *c*, cylindrical chamberlets of intermediate zone; *h*, *h′*, upper and lower annular galleries; *i*, *i′*, upper and lower superficial chamberlets; *l*, the calcareous partitions.

nications between any of the chambers, which seem to be quite independent of one another. The floors of these chambers are formed by the expanded summits *l l*, *fig* 21, of the septa separating the chambers of the intermediate layer, and the apertures in them lead into the two cavities on either side of each septum. At the point where the two apertures from contiguous chambers meet is a round aperture *h h'*, *fig.* 21, which corresponds with the circular galleries *h h*, *fig.* 20. These cavities are filled by the soft parts which have the form represented in *fig.* 22, in which is represented the segments filling the cells in the superficial layer. They are connected at the two extremities with the annular stolons, which occupy the circular galleries, *h*, *fig.* 20. From the under side of these stolons proceed the columns of sarcode, of which two rows are shown. The columns of one row are in many cases connected with those on either side by oblique peduncles passing alternately from one row to the other. Thus, by means of these peduncles, and of the annular stolons, every portion of the sarcode is connected together. We will again return to the shell. By referring to *fig.* 21, the intermediate stratum will be seen to consist of small chambers, *c c*, having the same *alternating* arrangement that prevails in the simple type. There is, however, a modification in their mode of communication with each other. In the simple type each chamber communicates with two chambers in the next inner row; but in the complex there appears to be a connection with only one chamber in the inner row, and one passage seems to run continuously in an oblique direction through several zones. The anomaly is apparent only, and may be explained by referring to *fig.* 22. Each segment communicates with segments in the next row by two distinct bands, that on the one side being on a higher horizontal plane than the other, but on the same plane as the corresponding band in the next segment. When a section is made, as in *fig.* 20, the bands on the right sides of the segments only are exposed, and these have a flexure in the same direction. If the section is made somewhat higher, the bands on the left side are exposed, and the flexure is in the opposite direction, as shown in the figure. In *fig.* 21, which is a vertical section of a disk of complex type, *b* corresponds with the central portion of *fig.* 20; at a short distance from which the first appearance of the intermediate stratum commences, and at *n* occurs the first duplication of the annular galleries. If the dots representing the intermediate stratum were omitted, the section between *b* and *n* would pass for that of an *Orbitolites* of simple type. Beyond *n*, the increase in thickness is almost entirely due to the growth and differentiation of the intermediate stratum. As described, there would appear to be sufficient grounds for assigning the two types of shells to at least two distinct species; but such a course would result in error, since the two types are, as it were, amalgamated together on comparing a large number of specimens; *fig.* 24 is a horizontal section of *Orbitolites*.

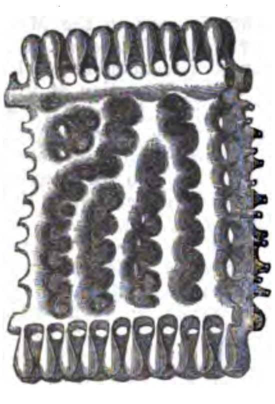


Fig. 22. Portion of sarcode body of *Orbitolites* of complex type.

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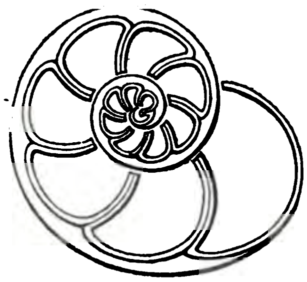

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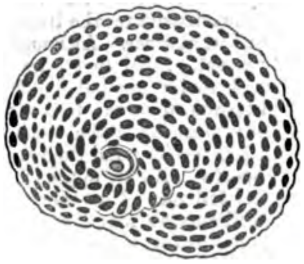

Fig. 23. Section indicating the bilaminated structure of the septa. Fig. 24. Horizontal section of *Orbitolites*.

The shells belonging to the types hitherto noticed are all easily recognisable from their opaque white porcelain-like aspect when viewed by reflected light, and their brown or amber colour when looked at in thin slices by transmitted light. Another feature which they possess in common is that the pseudopodia do not issue from the general surface of the body, but from a single or multiple aperture. Hence they are assigned to the sub-order *Imperforata*. But there is another large group of *Foraminifera*, in which the shell is of a *vitreous* or *hyaline* appearance, and is perforated by tubular openings for the emission of the pseudopodia. There are differential points of much importance. Thus in higher forms of the hyaline series there is a supplemental skeleton, formed by a secondary deposit upon the outer walls of the chambers; this skeleton is traversed by a set of canals, usually arranged on a systematic plan. These passages are *sinuses*, and not vessels. Again, it is only in the *hyaline* series that each chamber has a shelly wall of its own, so that each septal plane is composed of two lamellæ, as in *fig.* 23. In the *porcellanous* series one lamella serves to divide two chambers. There is also a striking difference in the connection between the successive segments in the imperforate and perforate series; "the communications between the successive annuli in the former, and between the outermost annulus and the exterior, being so numerous and free, as to amount in the aggregate to a large apertural area; whilst in the latter they are so much more restricted as to be not readily discoverable. This tendency to a more complete separation of the segments shows itself yet more strongly in regard to the transverse sub-division of the principal chambers in *Orbiculina* as compared with *Heterostegina*, and in *Orbitolites* as compared with *Cycloclypeus*; for in the two imperforate types we find this transverse sub-division so far from complete, that it resembles that of a long dormitory, in which the beds (arranged in rows on the two sides) are separated from each other by partitions that extend from the walls towards the central line of the apartment, but stop short of it, so as to leave a free passage from one end of it to the other; whilst in the two perforated types the chamberlets of each row are entirely cut off from each other laterally communicating only with those of the rows behind and in front of them. Thus we see that, whereas in the imperforate shells the nutrition of the entire body is derived from the alimentary materials obtained by the last segment alone, every segment in the perforated shells is capable of obtaining at any rate a portion of its supply for itself; and hence a much greater degree of individualisation of the segment is possible in the latter case than in the former." The genus *Carpenteria* is remarkable for its external resemblance to the *Balani*, and for possessing sponge-like spicules. It seems to be well established that the spicules belong to *Carpenteria*, and are not of extraneous origin.

The greater insight that has recently been afforded us into the physiological importance of the various parts of a Foraminiferous animal, has rendered the systematic arrangement proposed by D'Orbigny unsatisfactory. In 1854, Max Schultze proposed a plan which was an improvement upon D'Orbigny's, but it is far from satisfactory. The work in which it appeared (Ueber der Organismus der Polythalamien (*Foraminiferen*) nebst Bemerkungen über die Rhizopoden in allgemeinen. Leipzig, 1854) is one of the most important recent contributions to our knowledge of *Foraminifera*. The two most recent classifications are those by Professor Bronn and Dr. Carpenter. Bronn's is chiefly based on D'Orbigny's, with a few modifications as proposed by Schultze. The following is Dr. Carpenter's classification. The definitions are not given by the author, but are drawn up from the remarks scattered over his work :—

CLASS RHIZOPODA. ORDER RETICULARIA.

Suborder I. IMPERFORATA.

Shell membranous, porcellanous, or arenaceous; pseudopodia extended through a single or multiple orifice at the anterior portion of the body.

FAMILY 1. GROMIDA. Body enclosed in a unilocular membranous test.

Genera: ***Lieberkuhnia.***
Gromia.
Lagynis.

FAMILY 2. MILIOLIDA. Shell calcareous, porcellanous, imperforate.

Genera: ***Squamulina.***
| |
Nubecularia. Cornuspira.
| |
Vertebralina. Miliola.
| |
Peneroplis. Hauerina.
| |
Orbiculina. Fabularia.
| |
Alveolina. Orbitolites.
Dactylopora.
Acicularia.

Family 3. Lituolida. Body enveloped in a layer of arenaceous cement substance.

Genera: *Trochammina.*
Lituola.
Valvulina.

Sub-order II. **Perforata.**

Shell calcareous, vitreous or hyaline; pseudopodia protrusible from all parts of the body through numerous scattered pores.

Family 1. Lagenida. Shell substance vitreous, finely tubular. Chambers flask-shaped, with margin of aperture usually everted or radiated. Septa single. No canal system or intermediate skeleton.

Lagena.
Orthocerina.
Uvigerina   *Nodosarina.*   *Polymorphina.*
Lingulina.   Nodosaria.   Glandulina.
Dentalina.
Vaginulina.
Rimulina.   Planularia.   Frondicularia.
Marginulina.
Dimorphina.
Robulina.   Cristellaria.   Flabellina.

Family 2. Globigerinida. Shell coarsely perforate. Septa single or double. Chambers usually connected by crescentic apertures.

Ovulites.   *Orbulina.*   *Spirillina.*
Textularinæ.   Globigerinæ.   Rotalinæ.
Bulimina.   *Textularia.*   *Globigerina.*   *Discorbina.*   *Cymbalopora.*
Virgulina.   Bigenerina.   *Planorbulina.*   *Calcarina.*
Bolivina.   Gaudryina.   Truncatulina.   *Tinoporus.*
Sphæroidina.   *Pullenia.*
Verneuilina.   Planulina.   *Patellina.*
Grammostomum.   Anomalina.   *Polytrema.*
Cassidulina.   *Cuneolina.*   *Pulvinulina.*
Rotalia.
Ehrenbergina. *Chrysalidina.*   *Carpenteria.*

Family 3. Nummulinida. Shell dense, with very minute tubuli. Double septal laminæ in all but *Amphistegina.* Intermediate skeleton and canal system well developed. Plan of growth usually spiral.

Amphistegina.
Polystomella.   *Nummulina.*
Nonionina.   Operculina.
Fusulina ?   *Heterostegina.*   Cycloclypeus.   Orbitoides.

In the above, the names in italics are those of accepted genera; the others are regarded as synonyms. It will be seen that this system differs widely from D'Orbigny's, given in the Cyclopædia. For instance, compare what would be the distribution of the genera forming the family *Globigerinida.* We find a few in almost every order :—

Order 1. *Monostega.* *Orbulina.* *Ovulites.* *Spirillina.*
Order 2. *Cyclostega.* *Tinoporus.* *Patellina.*
Order 3. *Helicostega.* *Globigerina.* *Carpenteria.* *Pullenia.* *Bulimina.* *Chrysalidina.* *Rotalina.*
Order 4. *Entomostega.* *Cassidulina.*
Order 5. *Enallostega.* *Textularia.* *Cuneolina.*
Order 6. *Agathistega.* *Sphæroidina.*

Professor Reuss also has proposed an arrangement which agrees with Dr. Carpenter's in most of the more important points, as will be seen from the following sketch :—

- A. Foraminifera with imperforate shell.
  - *a.* Shell arenaceous.
    - 1 *Lituolidea.*
    - 2 *Uvellidea.*
  - *b.* Shell calcareous, porcellanous, compact.
    - 1 *Squamulinidea ?*
    - 2 *Miliolidea.*
    - 3 *Peneroplidea.*
    - 4 *Orbitulitidea.*
- B. With perforate shell.
  - *a.* Shell calcareous, vitreous, finely porous.
    - 1 *Spirillinidea.*
    - 2 *Ovulitidea.*
    - 3 *Rhabdoidea.*
    - 4 *Cristellaridea.*
    - 5 *Polymorphinidea.*
    - 6 *Cryptostegia.*
    - 7 *Textilaridea.*
    - 8 *Cassidulinidea.*
  - *b.* Shell calcareous, with multiple pores.
    - 1 *Rotalidea.*
  - *c.* Shell calcareous, traversed by a ramifying canal system.
    - 1 *Polystomellidea.*
    - 2 *Nummulitidea.*

The *Eozoon* from the Laurentian rocks belongs to the Globigerine family, but its place in the series is doubtful. We should be inclined to place it between *Calcarina* and *Tinoporus.*

The *Foraminifera* occur in all parts of the world, but the most widely spread genera are *Miliola, Textularia,* and *Globigerina.* The former two are sometimes found in deep waters, but are best developed at moderate depths, and in tropical climates. The last is rare on sea shores, but occurs in remarkable abundance in the deepest parts of the ocean. Thus the ooze brought up by Captain Dayman from a depth of 2000 fathoms in the Mid-Atlantic consisted almost entirely, 97 per cent., of *Globigerina.* Dr. Wallich's observations on the soundings off Greenland at depths of 1260 and 1607 fathoms, also yielded a like proportion of this genus. The ooze appears to consist of a surface layer of living individuals, and a substratum composed of the exuviæ of the generations that have passed away. The *Globigerinæ* are not so widely spread as *Miliola* and *Textularia.* They do not occur in much abundance beyond the limits of the area occupied by the Gulf Stream. Thus they seldom exceed 50 per cent. of the ooze from the deeper parts of the Mediterranean, Red Sea, East and west coasts of South America, and elsewhere. The enormous aggregate number of these beings is perhaps not so extraordinary as their density of population. Thus in one ounce of sand from the Adriatic, Soldani found 6000 individuals; in an ounce of sand from Molo di Gaeta, Schultze found 1,500,000; and in an ounce of Cuban sand D'Orbigny found 3,840,000 individuals. The *Globigerinæ* from the Atlantic are frequently studded with oval bodies, or *coccoliths,* whose average length is about 1-2700th of an inch. Some specimens have a single aperture, others have the aperture divided by a central band, which gives them a quoit-like appearance. The *coccoliths* are loosely attached to the *coccospheres,* so that they easily become detached. Hence they form a considerable proportion of some deep sea deposits. Similar bodies have been found in the Chalk. What relation they bear to the species to which they are attached has not been clearly ascertained. Sometimes several species occur in connection, apparently growing on the Nodosarian or on the Textularian mode of growth. The most highly organised *Foraminifera* preponderate in the tropical seas, and many genera are entirely restricted to them;—as for example, *Orbiculina, Alveolina, Orbitolites, Calcarina, Amphistegina,* and *Heterostegina.* This fact is also shown by the following figures given by Bronn, who thus distributes the living species, which, according to him, are 826 in number. Although most of these species are probably only varieties, still that does not affect any conclusion we may draw as to the general distribution of the *Foraminifera.* The Mediterranean seems to be remarkably rich—it contains 273 species; next come the West Indies, between 15° and 23° N., with 169 species; and then the East Indies and South Sea, with 117 species. As we approach the colder latitudes the numbers rapidly fall off. Thus Great Britain is said to have 39 species (in Williamson's monograph, 59 are described); and the North Sea, off Norway, between 64° and 72° N., 31 species. As far as England is concerned, the present distribution seems to have prevailed during the post-pliocene and recent epochs; but before the glacial epoch several tropical types dwelt on our shores, as evidenced by their remains in the coralline crag of Sutton and Sudbourne.

There is little to be added respecting the geological distribution of these creatures. They appear to have existed as far back as geologists have been able to trace any signs of life. The earliest known form is the *Eozoon Canadense;* and this, it should be noticed, has a skeleton of so great a complexity as to entitle it to rank near the top of the Foraminiferal series. Several points of its structure correspond with the essential characteristics in the principal typical forms of *Foraminifera.* In the structure of the septa it agrees precisely with *Nummulina;* its intermediate skeleton and elaborate canal system find a close parallel in *Calcarina;* the mode of communication between the chambers much resembles what is found in *Cycloclypeus.* Dr. Carpenter places it unhesitatingly in the Nummuline series, and thus points out its affinities :—"And it appears to me that *Eozoon* takes its place quite as naturally in the Nummuline series as *Polytrema* in the Rotaline. As we are led from the typical *Rotalia,* through the less regular *Planorbulina* to *Tinoporus,* in which the chambers are piled up vertically, as well as multiplied horizontally, and thence pass by an easy gradation to *Polytrema,* in which all regularity of external form is lost, so may we pass from the typical *Operculina* or *Nummulina* through *Heterostegina* and *Cycloclypeus* to *Orbitoides,* in which, as in *Tino-*

porus the chambers multiply, both by horizontal and by vertical gemmation; and from *Orbitoides* to *Eozoon* the transition is scarcely more abrupt than from *Tinoporus* to *Polytrema*."—('Quart. Journ. Geol. Soc.' vol. xxi. p. 65.) The following table shows the distribution of the *Foraminifera* :—

TABLE OF GEOLOGICAL DISTRIBUTION OF FORAMINIFERA.

	Periods.					
Families and Genera.	Palæozoic.	Triassic.	Jurassic.	Cretaceous.	Tertiary.	Recent.
Gromida	..	..	..	..	..	—
Miliolida	..	—	—	—	—	—
Squamulina . .	..	..	..	..	..	—
Cornuspira . . .	..	..	..	..	—	—
Nubecularia . .	..	—	—	?	—	—
Vertebralina . . .	..	..	..	..	—	—
Miliola	..	..	—	—	—	—
Fabularia . . .	..	..	..	..	—	..
Peneroplis . . .	..	..	..	..	—	—
Orbiculina . . .	..	..	..	..	—	—
Alveolina . . .	..	..	..	?	—	—
Orbitolites . . .	..	..	..	—	—	—
Dactylopora . .	..	..	..	..	—	—
Acicularia . . .	..	..	..	..	—	..
Lituolida	—	—	—	—	—	—
Trochammina . . .	—	?	—	—	—	—
Lituola . . .	..	—	—	—	—	—
Valvulina . . .	..	..	..	—	—	—
Lagenida	—	—	—	—	—	—
Lagena	..	..	..	—	—	—
Nodosarina . . .	—	—	—	—	—	—
Orthocerina . . .	..	..	—	—	—	—
Polymorphina . .	..	—	?	—	—	—
Uvigerina . . .	..	..	..	..	—	—
Globigerinida . . .	—	—	—	—	—	—
Orbulina . . .	..	..	..	..	—	—
Ovulites . . .	..	..	..	..	—	..
Spirillina . . .	..	..	..	..	—	—
Globigerina . .	..	..	..	—	—	—
Pullenia. . . .	..	..	..	—	—	—
Sphæroidina . .	..	..	..	—	—	—
Carpenteria . . .	..	..	?	?	..	—
Textularia . . .	—	..	?	—	—	—
Chrysalidina . . .	..	..	..	—	..	—
Cuneolina . . .	..	..	..	—	..	..
Bulimina . . .	..	—	—	—	—	—
Cassidulina . .	..	..	..	..	—	—
Discorbina . . .	..	..	..	—	—	—
Planorbulina . .	..	..	—	—	—	—
Pulvinulina . . .	..	—	—	—	—	—
Rotalia	..	..	..	—	—	—
Cymbalopora . . .	..	..	..	—	..	—
Calcarina . . .	..	..	..	—	—	—
Tinoporus . . .	..	..	..	—	—	—
Patellina . . .	..	..	..	—	—	—
Polytrema . . .	..	..	..	..	..	—
Nummulinida . .	—	..	..	—	—	—
Amphistegina . .	..	..	..	..	—	—
Operculina . . .	..	..	..	—	—	—
Nummulina . . .	..	..	..	..	—	—
Polystomella . .	..	..	..	—	—	—
Heterostegina . .	..	..	..	..	—	—
Cycloclypeus . .	..	..	..	..	—	—
Orbitoides . . .	..	..	..	—	—	..
Fusulina . . .	—	..	..	..	..	..
Eozoon	—	..	..	..	..	..

In numerous instances the fossil species are represented not only by their shell remains, but also by casts of their soft parts. The existence of these casts was first announced by Professor Bailey in 1845. In 1853 Ehrenberg showed that the body of the animal, even to the minutest ramifications in the canal system, was replaced by silicate of iron, and that a large proportion of the glauconitic granules, which give a greenish tinge to various sands and sandstones occurring in all the geological formations from the Silurian up to the present time, are for the most part internal casts of *Foraminifera*. During the United States survey of the Gulf Stream soundings were taken. In some cases the sediment brought up was found to be composed of about equal proportions of *Globigerina* and black green sand. All the specimens of black sand examined contained numerous green, red, and white casts of *Foraminifera*, evidently belonging to recent species, as several of the shells in the same sediment still retained their soft parts. Pourtales has observed the deposition of glauconite in other organisms, as in the cavities of Millepores, and the canals in the shells of *Balanus*. He states ('Rep. Amer. Coast Survey, 1858') that the glauconite grains in *Foraminifera* are gradually denuded of their calcareous envelopes, and ultimately become "conglomerated into small black pebbles," sections of which still show under a microscope the characteristic spiral arrangement of the cells. The *Eozoon* appears to have been preserved by precisely the same process as is going on now at the bottom of the Atlantic. Its soft parts have been replaced by silicates, while the calcareous skeleton is very little altered. By dissolving away the carbonate of lime the silicates are exposed, and these give an accurate cast of the original sarcode. In the *Eozoon* the silicates are a white pyroxene, a green serpentine, and a green loganite. The most perfect casts are given by the serpentine. It may be noticed that the replacing silicates are those of lime and magnesia, not iron. No glauconite (silicate of iron) has yet been found in the Laurentian rocks; it first appears in the lower Silurian beds, but is most abundant in the secondary, tertiary, and recent deposits, in all of which it seems to have a close connection with organic forms. Little is known respecting the development of the *Foraminifera*. The ordinary mode appears to be by the detachment of portions of the sarcode body, as in the case of *Amœba*, in which the terminal ends of the pseudopodia are left attached to some foreign object. These bits rapidly assume the form and habits of the parent mass. In *Orbitolites* aggregations of minute spherules sometimes appear in the sarcode, which it is supposed may have some relation to the reproductive process. Schultze has noticed in specimens of *Miliola*, which he kept under constant observation, that they threw off a slimy substance containing well defined granules. These granules loosened themselves and spread to a slight distance round the parent body. On examining them with a lens, they proved to be young *Miliolæ*. A representation of one is given in *fig.* 2. A like phenomenon has been observed in *Rotalia*. Dr. T. S. Wright has found the young of *Spirillina vivipara* in the interior of the shell of the adult; and Dr. Carpenter has met with a number of young *Orbitolites* occupying the central portion of a large specimen. How these young are produced, whether by a sexual act or by the breaking up of the parent body, has not been ascertained. Some observations have been made tending to show that the former alternative is the correct one. Thus in *Gromia*, *Cornuspira*, *Miliola*, *Rotalia*, *Orbulina*, there are frequently bodies resembling the *primitive ovum* of Acalephæ. Four of the segments of a *Truncatulina* contained one ovum each, and in these the germinal vesicle and spot could be distinctly seen. The ova are too large to escape by the apertures of the chambers, and it is believed that they may undergo the same change as the similar body in *Amœba verrucosa*, the ovum of which breaks up into amœboid zooids sufficiently small to escape through the usual apertures.

Carpenter, *Introduction to the Study of the Foraminifera*, 1862; Greene, *Manual of the Protozoa*, 1863; Bronn, *Die Klassen und Ordnungen des Thier-Reichs*, *Band* i. 1860; *Quart. Journ. Geol. Soc.*, vol. xxi. 1865; *Nat. Hist. Rev.* July, 1863; Williamson, *On the Recent Foraminifera of Great Britain*, 1858.

FREESTONE. [Sandstone, E. C. S.]

G

GENERATIONS, ALTERNATION OF [E. C. vol. i. col. 137; vol. ii. cols. 949—953]. Further examples of this phenomenon are given under ANNELIDA, APHIS, ENTOZOA, and HYDROZOA, in the E. C. S. The term employed to denote it is not a happy one, and several others have been proposed instead of it, such as geneagenesis, &c. Professor Steenstrup made it embrace ideas which ought to be carefully kept distinct. Thus he cites *Aphides*, *Entozoa*, *Hydrozoa*, and bees as groups of beings which reproduce by what he terms alternation of generation; but the character which is common to all the modes of reproduction possessed by these creatures does not satisfy what seems to be the idea usually conveyed by these words. In ordinary generation, or rather in the mode of generation exhibited by those organisms which are most familiar to us, viz., the vertebrate, the ovum produces a compact individual mass, which resembles in form the parents which generated the ovum. This individual retains its singularity throughout life, and by the intervention of a second individual the circle is completed by the fecundation of another ovum. In the Bee the process of development is more varied. The parents produce eggs; from each egg is developed an individual widely different from its progenitors, and, moreover, two or more different forms of young are the offspring of a common parentage. These young become mature, and perform their peculiar functions in inducing the formation of a fresh batch of ova. In the vertebrates every individual is potentially capable of taking a direct share in the generative process; but amongst the bees a portion of the brood does not acquire perfect sexuality, but aids in the continuance of the species by feeding the young or performing other tasks conducive to the general welfare. In the *Aphididæ, Annelida, Entozoa, Hydrozoa*, and other groups, the developmental process is more complicated. In these an egg produces a zooid; the zooid gives rise to other zooids by gemmation; and these zooids undergo various changes of form prior to their acquiring sexual maturity. In the *Aphides* the metamorphism is simple and slight; but in *Entozoa* and *Hydrozoa* it is complex and great. In Bees, as in man, the multiplication of individuals is effected by the mature sexes only. In the *Hydrozoa*, &c., individuals originate only from sexes, if by 'individual' be meant the educt of each ovum. In the Bee the individual is single; but in the *Hydrozoa* and some other invertebrate classes the individual consists of numerous zooids. The non-sexual zooids reproduce their kind without the intervention of eggs. The Bees, then, differ from the *Hydrozoa*, *Entozoa*, &c., essentially in some features of their generation, but agree with them in undergoing polymorphic development, and in consisting of polymorphic zooids; but this many-formedness which constitutes their common feature is not alternation of generation. The phenomenon which in *Hydrozoa*, &c., constitutes alternation of generation is the occurrence of gemmating zooids succeeding others which generate by eggs; in this respect they differ from the Bees; and hence, as we said above, it is desirable to place the mode of generation amongst Bees in a distinct category from that amongst *Hydrozoa;* and to keep polymorphism distinct from geneagenesis. Further caution, moreover, seems requisite to prevent the term alternation of generation from giving rise to misconception. Thus the alternation of generation which is presented by all the groups known to exhibit it consists in one *form* of the individual multiplying by a non-sexual process, and a different form generating sexually. This is quite a distinct thing from what some persons imagine the term to imply, viz., the alternate occurrence of two *forms* of the individual, both of which reproduce sexually, no example of which phenomenon has yet been established. In this article we have based our remarks upon the consideration that gemmation is radically distinct from ovulation; but it is possible, as hinted under APHIS, E. C. S., that both these generative processes have a closer relation than is usually supposed, and that both may be sexual operations.

GEOGRAPHICAL DISTRIBUTION OF ANIMALS.— Details respecting the distribution of living animals in space are scattered under the names of the classes, or families, or genera. In this place we wish to make a few observations, which, as they do not exclusively concern any one group, may be brought together here.

It is a manifest truism that every species does not occur in every locality; it is also well known that the various animal classes are not equally represented in every region; and hence it is obvious that so far as space alone is concerned, there is an inequality in the distribution of animals. This inequality manifests itself in many ways. Some creatures live in the water, others on the land, and others again dwell both on land and in water. Of the aquatic tribes, some are confined to fresh water, many to the sea, while a few species constantly pass from the sea to the fresh waters and back again. On comparing the fauna of one region with that of another, it is observable that one possesses species not possessed by the other; and when the examination of many faunas is carried on it is perceptible that the limits of each species or each group are regulated by some law or laws. And as the inquiry is pursued the student becomes impressed with the conviction that all the differences, even the minutest, are explicable in some way. The study is, however, very incomplete, and one great defect is, that it is chiefly confined to the living species, whereas it is essential to the due understanding of the distribution as it is now that every effort be made to ascertain what it has been in times past.

The geographical distribution of animals throws much light upon many scientific questions, such as the evolution of species, the mutations of land and water, the relation between the fauna and the climatal, orographical, botanical, as well as the zoological conditions, amidst which it is situated. The fauna is related not to any one set of conditions, but to all; and the nature of the relationship varies for each district and for each fauna. Further, it would seem that the character of the fauna is, in great measure, dependent not only upon the conditions to be observed now, but also upon all those which have been in operation during the existence of the species, the genus, or the family. When the difficulties of an animal passing from South Africa to South America are considered, it seems natural that the animals of the one district should be wholly distinct, as regards species, from those of the other. But, at first sight, it is difficult to comprehend why Celebes and the Australian region should possess a fauna as distinct from that of Borneo, as are those of South America and South Africa; nor do we readily see why South Africa itself should have so different a group of beings from the northernmost part of that continent. Again, it is remarkable that there is a far closer relation between the mammals of South Africa and India, than between those of South Africa and North Africa. For instance, taking mammals only, the New World has many families which are entirely unrepresented anywhere else. There are several families found in South America, and not in North America, but the latter district possesses no family which has not its representative in the latter. This conforms in a great degree with the present configuration of the land. Many families are common to the South African and Indian regions, and restricted to them; and there is scarcely a family found in the one which does not occur in the other. Hence the difference between the faunas is chiefly generic. Europe and North Asia possess no families, of which some forms do not extend into Africa or India; and the forms which are peculiar to the Europæo-Asiatic region are only generally distinct from those of the Indo-African region. This distribution does not conform to the present arrangement of the land, and seems to indicate that formerly South Africa was more closely connected with India, and less so with North Africa, than it is at present. There is, then, an interesting parallel between the Old and New Worlds, for in both all the northern families range into the southern areas; and in both it is the latter areas which have in addition a number of families peculiar to them. The same phenomenon is to be noticed in birds, reptiles, fishes, and probably many other classes. Thus, in the case of birds, the species are far more crowded in the south than in the north. The northern regions, which together comprise about 21 million square miles, have 1110 species, according to Sclater's estimate in 1858; while the southern regions, which in the aggregate have a land surface of about 24 million square miles, are inhabited by about 6000 species. The districts richest in species are India and South America. Again, amongst fishes, of which 8000 species are known, upwards of 2000 have been found in India only; and South America also has a remarkably varied piscine fauna. Of the many coincidences which coexist with this arrangement, climate, at any rate, does not seem to be the most important; and although no one condition, or peculiar set of conditions, should be specially referred to as the main cause of the arrangement; yet there seems to be a close connection between the degree of isolation of the land and the variety of the fauna. Another remarkable feature of these living faunas of the south is that they have a more antique element in them than those of the north,—that is, the nearest living representatives of the oldest extinct vertebrate species of the north are nearly always resident in South America, or South Africa, or South Asia and Australasia, and very rarely in the northern hemisphere. Thus, to cite one or two examples, the nearest living relative of the *Archæopteryx* is the *Chauna derbiana* of Brazil; the nearest allied recent representative of the triassic *Telerpeton* of Great Britain is the *Hatteria* of New Zealand; the *Osteolepis* of the Old Red Sandstone is not very different from the *Polypterus* of African rivers; and we might give illustrations from many other families. We do not mean to say that the antique types do not exist in the north, but that they are much more abundant in the south. Neither do we mean to urge that climate has an unimportant influence in regulating distribution; for amongst European animals there are many facts which show a close connection between the boundary of a species, or group of species, and the temperature. Thus, we may refer to the range of the reindeer [CERVIDÆ, E. C. S.]; and to the gradual increase in the number of genera and species of fishes and molluscs in passing from north to south. Thus, there are 120 genera of fishes in Scandinavian seas, 130 in those of Great Britain, and 227 in the Mediterranean. Again, the mollusca (exclusive of nudibranchs and tunicates) increase from 116 genera in the north, to 129 in British seas, and 155 in the Mediterranean sea.

We have said that the present distribution of animals throws much light upon the former alterations in the position and connections of land and water. Each class probably teaches much in common with other classes, but in addition, it indicates something which the others do not. Hence, caution is required in applying too generally the indications drawn from any one class. No group is so well known as mammals, and it is probable there are fewer species undiscovered in this than in any other class. Hence the distribution of this group reveals things more clearly than that of any other; and on this ground we preferentially select a few facts from it.

Living monkeys are restricted to warm climates. Their northern limit is about 20° N. lat. in America and Asia; and 35° N. lat. in the Mediterranean area, where they extend to the African borders of that sea, while one species is sparingly represented in Gibraltar. Formerly they existed much farther north in Europe. The greatest density of species occurs a few degrees on either side of the equator in America, Africa, and Asia. The southern limits are La Plata in America, the ocean south of Africa, and the islands off North Australia. Monkeys, however, are not known farther east than Celebes in the south, and Japan in the north. The American monkeys form a group distinct from the Old World species; the latter constitute the *Platyrhini*, and range from the west coast of Africa to the extreme eastern limits of the order. The same difference has obtained as far back as monkeys have been traced, or the miocene, perhaps the eocene, period. From these facts we draw the hypothesis that there has been no land connection between Africa and America which would permit monkeys to pass from the one continent to the other; we might hazard a more general hypothesis, and infer that there has been no land connection between America and Africa anywhere within the parallels of 30° on either side of the equator; and might even venture still farther, and extend the northern limit to the 50th degree of latitude. The catarhine monkeys stretch from West Africa to Celebes, and on all the principal intermediate islands. This seems to point to the existence of a continuous land surface between these two extremes since the eocene period. The continuity may have been contemporaneous, or epochal. Our meaning will be clearer if we restate the phrase in another way. There may have been a continuity of surface from Africa to Celebes at one and the same time; or Africa may have been connected with Madagascar, Arabia, and India, at the same moment; subsequently India may have been disconnected from Africa, and then connected with Sumatra and Celebes. It is this latter kind of continuity that we have termed epochal. This connection has, as the facts seem to indicate, occurred during the existence of the anthropoid apes, which now occupy three separated areas, viz., the West Coast of Africa, Sumatra, and Borneo. The baboons also occur in separate areas, viz., the southern two-thirds of Africa, the Philippine Islands, and Celebes. The family *Lemuridæ* occurs in Africa, Madagascar, India, and the eastern portion of the Malay Archipelago. Gray divides it into two sections, the *Indrini* and *Lemurini*. The former consists of two genera, *Indri* and *Propithecus*, both of which are restricted to Madagascar; of the *Lemurini* the genera *Varecia*, *Lemur*, *Macrorhinus*, *Hapilemur*, *Cheirogaleus*, *Lepilemur*, are restricted to Madagascar; and the other genera are confined to limited African regions, with the exception of *Galago*, of which a doubtful species is recorded from Madagascar. Madagascar is the headquarters of the group, and we should surmise that Madagascar was once connected with Africa, and that the separation occurred before the establishment of the present genera, but subsequent to the differentiation of the two tribes.

The *Carnivora* have a range which enables us to support the indications drawn from monkeys, and to advance a step or two farther. Our knowledge of the extinct forms is necessarily scanty and imperfect, but in pre-glacial times they occupied widely separated tracts, or rather their fossil remains have only been found in such tracts. They are the central portion of North America, Southern Europe, and Northern India. These tracts occur within a narrow latitudinal band immediately to the north of the range of living monkeys. One genus, viz., *Machairodus* was represented in the pliocene period both in America and in Europe, but by different species. From this we infer it as possible that there has been land connection between America and Europe within the time of this genus, and in a latitude inhabited by it. What the extreme range of the genus was there is no telling, but the remains are confined between 40° and 54° N. lat. in both continents. The connection may have been within these latitudes, but from other circumstances it was probably somewhat farther north, or between 50° and 60° N. lat. The little we know about the large carnivores indicates that their range has been diminishing for a long time past, and that their northern limit has been retreating southward. The lion and the tiger, the principal representatives of the genus *Felis*, occupy distinct areas which just overlap. The lion roams, or did within the memory of man, throughout Africa, Arabia, Persia, and North-West India. The tiger begins in Persia and roams throughout India, Thibet, China, Sumatra, and Java; but does not extend into Ceylon or Borneo. The distribution of the leopards and jaguars is almost the same as that of the monkeys; one important difference is that these carnivores do not occur in the islands east of Borneo and Java. But there is one significant fact which is certainly difficult to explain, but which we imagine is an important clue to the past distribution of the group. *Felis irbis* is one of the most characteristic animals in Thibet and Siberia. *Felis onca*, the jaguar, is exceedingly like it, and occurs in Central America. Murray says of them "that their physical resemblance to each other is too great to allow any one to doubt that they have been derived either from a common ancestor or one from the other. How, then, are we to account for their being found on opposite sides of the Atlantic or Pacific. The closeness of their resemblance naturally suggests a recent divergence from the common stock, and we might expect that their distribution is due to the ancestors of the one or the other having found their way across from Europe to America, or from America to Europe, after the retreat of the glacial cold, and before the bridge afforded by the miocene Atlantis had been broken down. But unfortunately for this view we know that this bridge was severed before mammals had become established sufficiently far north to avail themselves of it. It is only northern plants and insects which have found the way from Europe to America after the return of warmth. If it had been open for the leopard it was also open for the cave lion and the cave hyæna, and their absence in America is a strong presumption against such a bridge being then open. We are thus driven to refer the origin of these leopards in both hemispheres to a period antecedent to the glacial epoch. The smaller cats are about equally divided between southern Asia and South America. The hyænas, so far as the facts go, are only known in the Old World, but they extended much farther north in the post-pliocene period than they do now. The *Canidæ* are worldwide; but the distribution of its subsidiary groups corresponds nearly with the great mammalian regions as understood by Murray. The true wolves stretch all across the land of the northern hemisphere north of 30° lat. in America and a somewhat higher latitude in Asia, but they rarely go farther north than the Arctic circle. They existed within the historic period in the British Isles; the dog-wolves are confined to South America; the jackals to Africa and South Asia; and the dingo to Australasia. The *Mustelidæ* are very generally distributed, occurring throughout America, Europe, Asia, and many parts of Africa. They are absent from the Australian region, as also from Madagascar and Ceylon. The great preponderance of species is in the northern temperate zones of America, Europe, and Asia, and most of the tropical species abound most in the coldest habitats of their region. The great stronghold of the family is America, where one half the species are found; one sixth of them are natives of southern Asia; one ninth are restricted to northern Asia; another ninth belong to Africa and the Mediterranean district, and the remaining ninth are scattered over the northern parts of Asia and America. Several genera are common to North America and Europe; from which we gather the same hypothetical inference as we did from the distribution of the *Felidæ*, namely, that there has been a northern connection between Europe and America in middle latitudes since the origin of these genera. The ratel ranges from the Cape of Good Hope to Arabia, Persia and North India. The *Ursidæ* form a compact group, that is, the species are closely allied one to another, and hence their distribution is calculated to afford valuable testimony. The common bears, *Ursus*, occupy nearly the same area as the wolves, but with a more southward extension. *U. arctos* formerly occurred in Britain, and extends all across the Europæo-Asiatic continent, and although the bear is a good swimmer, this fact would lead to the conjecture that before the species became extinct in Britain, and subsequent to its appearance as a species, England was united with the continent. This conjecture is abundantly verified by other facts. Closely allied to the European brown bear is the *U. ferox* of America; and this again points to the circumstance that since the pliocene period the bears have been able to communicate between Europe and America. It might be suggested that this communication was and is by water; but the circumstance that the American bears are not quite the same as those of Asia or Europe would indicate that the two groups are now isolated. Moreover, if it be true that the extinct *U. priscus* of Europe is the same as the *U. ferox* of America, as has been urged by recent anatomists, this points to a closer connection between the continents formerly than now. It is somewhat difficult to be confident as to the correct determination of species, upon which a great deal depends, and hence too much reliance should not be placed upon the truth of the conclusions drawn from their distribution.

The *Equidæ*, so far as known, appear to have had a remarkable distribution. All the indigenous living species are confined to South and East Africa and southern Asia. Nowhere do they reach much farther north than 50° N. lat. The extinct species have been found in South Europe, their northern limit being about 54°. Crossing the Atlantic the extinct species occupied the area between 23° and 50° N. lat. and the whole of South America. The extinct *Equidæ* thus occupied three distinct tracts, none of which areas coincide with that on which the living species are found. Do these tracts represent centres of creation? We imagine not. And, as one instance in favour of their former connection in some way, it may be noticed that *E. curvidens* has been discovered both in South America and in the United States; and that the species most nearly allied to it is the quagga, which is confined to the southern extremity of Africa. Resorting to conjecture, not however in a random way, but according as the facts appear to point, we should suppose that *Equus curvidens* has passed from South America to the United States; that this species or an allied one has crossed by land from the United States to Western Europe and North Africa, and that this has been replaced by the quagga. One good fact in support of this view would be the occurrence in the later tertiary strata of Europe of a horse connecting *E. curvidens* with the quagga, or of either of these species. The distribution of the living and extinct *Camelidæ* is somewhat analogous to that of the horses, in that the living and extinct forms occupy different areas. The living species dwell in the tract extending from China on the east, through Thibet, North India, Persia, and Arabia, to North Africa on the west. The northern limit is about 43° N. lat. Another portion of the family dwells on the Andes from the Equator to 54° south of it. The extinct species have been found in North Asia, North America, and South America. Murray has some remarks upon this group, which we quote. "The camel is a very ancient beast, one of the oldest, if not the oldest, species of mammal now living on the face of the earth, and it has apparently always been, as at present, a servant of man. Other domesticated animals—the dog, the elephant, the horse, the ox, and the sheep—have, with greater or less success, been referred by naturalists to their original wild types; but all attempts to do so with the camel have stopped short at the threshold, from the simple fact that it is sole and singular, and has no allies in the hemisphere in which it is found, nor have any wild species of its own genus ever been met with. The first accounts of it, in perhaps the oldest book in the world (Job), speak of it as domesticated, and there are no accounts of its ever having been otherwise. But Sir Proby Cautley and Dr. Falconer discovered in the Sevalik formations in the Himalayahs remains of it, or of species (they think there are two) so closely allied to it as to be scarcely distinguishable from it. As the difference is so slight, it pleases us to think that we may have here in this most ancient animal, a species which saw the miocene epoch, and which has survived all the chances and changes which have taken place since then. Subsequent to that time another well marked species also existed, the huge *Merycotherium*, a monster, a giant, a camel as big as a camelopard. Possibly it may have been contemporaneous with the camel during the miocene period, but traces of it have only been met with in the Siberian drift. This may fairly be held to extend the range of the *Camelidæ* to the eastern bounds of Asia, and we find it taken up on the other side of the Pacific by the genus *Camelops* found in Kansas, and the genera *Procamelus* and *Leptauchenia* from the Mauvaises Terres on the Missouri, and carried down into Brazil by extinct species of the Guanaco, remains of which were found by Dr. Lund in the caverns of Brazil." The current evidence, then, it will be observed, so nearly bridges over the great chasm between the two areas occupied by the living forms that very little more is wanting to convince the student that the area of distribution of this family, if all were known, would prove to be a continuous land area. All the species are terrestrial, and so rarely take to water that one is not inclined to credit them with having extended their boundaries by swimming across large arms of the sea. It seems probable that the areas of all families are continuous, however much the members may now be scattered. The distribution of the *Bovidæ* is exceedingly scattered, but if, as many facts seem to show, the intermediate areas have at one time or other supported one or more species, we have another family to support the notion that Europe and America were once united. The musk-ox has usually been referred to this family, but many good authorities now consider it to be a sheep, and therefore no further allusion will be made to it here. The bison occurs in the central portion of the United States. It is represented in Europe by the aurochs, which, not many centuries back, was generally distributed in the temperate zone; and a species intermediate between it and the bison has been found in the post-glacial deposits of Northern Europe and Western Siberia. The gayal (*Bos frontalis*), occupies a small tract in North-east India, contiguous to those to which the gayour (*Bos gaurus*), and Bentang (*Bos sondaicus*), are restricted. The former occurs throughout India; the latter stretches from Birma through some of the islands of the Malayan Archipelago to Java. *Bos taurus* is distributed through various parts of Africa, Asia and Europe; *B. primigenius*, *B. longifrons*, and *B. frontosus*, belong to Western Europe.

Amongst the *Ovidæ* also there is one genus common to Europe, Asia, and America. Giebel recognises five species only of *Ovis*. *O. musimon* occurs in the countries bordering the north-east end of the Mediterranean sea; *O. tragelaphus* in North Africa; *O. argali* and *O. burrhel* in Asia; and *O. montana* in the Rocky Mountains. The *O. nivicola* of Kamtschatka may be a sixth species, and *O. sibirica* of the Altai Mountains a seventh. The goats have very nearly the same distribution as the sheep. The *Antilopidæ* occupy a continuous area, which extends from the Cape of Good Hope on the south to the Mediterranean on the north, and eastwardly as far as the Pacific Ocean. The species are most abundant in South Africa, less in Nubia, Arabia, India, and the Malayan Archipelago; and still less so in the countries farther north. Giebel arranges the species into 11 groups; each group generally occurs in one area. There is an exception, viz., the group *Bovina*, one species, *Anoa depressicornis*, occurring in Celebes, and a second, *Damalis oreas* in South Africa. The *Cervidæ* extend through Europe, Asia, and America. Several of the species frequenting high latitudes are common to America and the Old World. The swine (*Suidæ*) are essentially the inhabitants of warm climates, the head-quarters being the East Indies. Like most families whose range is more southern than northern, the American forms are generally distinct from those of other continents. When a family is more confined to the temperate zone there is a somewhat closer zoological relation; but when a family tends towards high latitudes, it is not unusual for closely allied, or even the same species, to occur in both America and the Europæo-Asiatic continent. The *Anoplotheriidæ* is an extinct family; remains of its species have been found in India, Western Europe, and North America, or the same distribution as that of the preglacial carnivores. This similarity in part arises from the sporadic distribution of the older tertiary mammalia-containing strata. The genus *Tapirus* consists of several species, of which some occupy an area widely separated from that occupied by the others. *T. americanus* has a wide extension in South America. *T. Laurillardi* probably inhabits Venezuela. *T. Bairdii* is also a Central American species. *T. Roulini* dwells in the higher ranges of the Andes, and is clothed with long, closely felted hair. *T. indicus* is confined to Sumatra, Malacca, and south-west China. This arrangement seems quite in harmony with the idea of special creation in distinct centres, and opposed to that of continuous areas for the same family. The gap is partially filled up by what we know of the fossil species, and we expect future researches will supply the deficiency. At any rate, fossil remains of existing species have been discovered in Texas; and relics of extinct species of the same genus have turned up in various parts of western Europe. On the hypothesis of continuous areas, this instance is strongly in favour of a land connection between western Europe and eastern America. The *Proboscidæ* existed during the miocene period in the United States, western Europe, and northern India. In the pliocene period they ranged from Patagonia to Russian America, and so by northern Asia to western Europe; while the existing species have lived in Europe, and are living in Africa and India. Who will trace out in what way and in what order these changes of distribution were effected? It would seem that in the upper miocene period there was an overland route from America to western Europe across the site of the Atlantic; that in pliocene times elephants and mastodons were able to bridge the chasm between America and Asia, and that since then the species peculiar to Africa has appeared on that continent. Murray has the following remarks as to when and where Africa probably derived its species:—"We may assume that it was not before the miocene epoch, as no evidence of the existence of any prior to that period has anywhere been found. If at the miocene period, then there must have been some other connection between Africa and other continents than what now subsists—for at that time there were elephants also both in North America and India; and the idea of three separate centres of creation is out of the question. It follows that a connection between Africa and some other country where pachyderms were, must have subsisted to allow of their appearance there; and as, for many reasons, a connection of Africa with India seems more probable than one with any [other] country, the pachyderms furnish additional confirmation of the hypothesis of a former connection with it. Dr. Falconer's views correspond with this in referring to India as the nursery of the European forms, both of African and Indian type. He says that if the asserted facts be correct, they seem clearly to indicate that the older elephants of Europe, such as *E. meridionalis* (of the African type) and *E. antiquus* (of the Indian type), were not the stocks from which the later species, *E. primigenius* and *E. africanus*, spring, and that we must look elsewhere for their origin; and that the nearest affinity, and that a very close one, of the European *E. meridionalis* is with the miocene *E. planifrons* of India; and of *E. primigenius* with the existing Indian species. That *E. primigenius* may have sprung from the present or some extinct Indian species seems extremely probable. As to *E. meridionalis*, we must remember if it is near to *E. planifrons*, so is *E. africanus*, all these belonging to the same section, and *E. planifrons* being the only Indian one with the African type." For our part the facts do not seem to indicate any closer connection between Africa and India than at present. For they show, first, that in post-pliocene times elephants had a high northern range, whereas now their range is restricted to the south; and next that both the Indian and African species of the present day formerly lived north of the Mediterranean. There is no obvious objection why the African species may not have entered from the north by the present land, or by the land which there is reason to think connected Italy and Sicily with North Africa. This is quite in harmony with what we know of the southern retreat of a portion of the post-pliocene fauna at and after the glacial epoch.

One of the peculiar features of the South American mammalian fauna is the great number of *Edentata* which it includes. Were Edentates restricted to South America, it might be urged that this order was specially created for this district, and that they never lived anywhere else. At present they are found from Patagonia to Texas in America; in South Africa; and again from the east coast and south point of India to Java and the Philippine Islands. Fossil species have been found in the United States between 20° and 50° N. lat.; and so nearly allied are they to South American forms, that it is probable they occupied a continuous area in some past geological time. A fossil species has been discovered in Europe, on which Murray thus remarks:—"One most interesting fact bearing upon this point [viz., the connection of America with other southern lands], is that the remains of an extinct edentate animal (named *Macrotherium giganteum*) have been found in the Old World (from miocene beds at Sansans, in the South of France, and at Linz), and although they are very imperfect, sufficient has been made out, first, to lead Cuvier to class them with the Pangolin; and now, when additional though still most meagre materials have been obtained, to cause Gervais to suppose them most akin to *Orycteropus;* lastly, to enable Professor Owen to say with confidence that they belonged to a gigantic genus intermediate between the *Manis* and *Orycteropus*. It is right to add, however, that this determination is not that of all palæontologists. Dr. Giebel finds no resemblance in the remains to those of *Orycteropus*. He thinks them much closer to the smaller armadillos. The determination of this point has much interest. If the animal was a pangolin, it shows that the only edentate fossils in the Old World belonged to the same type as still continues to inhabit it; while, if more nearly allied to the armadillo, it furnishes another instance, in addition to that of eocene opossums from the Paris gypsum, of a form supposed to be peculiar to South America having at that time also lived in Europe. Professor Owen regards its Old World relations (between *Manis* and *Orycteropus*) as deeply interesting, on account of the geographical position of both these edentate genera, viz., on tracts of land, which are now most contiguous to the continent containing the remains of the extinct osculant genus; but although most contiguous now, we must remember that at the time when *Macrotherium* lived, Africa was wholly disarticulated from Europe, and India probably from Asia; the communication between the country to the north and that to the south of the line of the Himalayan range and its extensions being apparently difficult or wholly interrupted. In fact, there appears to have been freer communication between the New World and the Old than between the Africano-Indian region and Europe."

The *Insectivora* occur in North America, but do not extend beyond the Arctic circle in Asia and Africa. The moles have a sporadic distribution, some being resident in the United States, others in the southern portion of Europe and Asia, and again others in South Africa. The group occupying each area belongs to a particular type;—*Talpa* representing Europe and Asia; *Scalops*, North America; and *Chrysochloris*, South Africa. One genus, however, is common to California and Japan. The frugivorous bats form one of the few families which connect Africa and India with Australia; and they constitute one of the few families represented on islands, occurring in Madagascar, the islands of the South Pacific, and others. The leaf-nosed bats occur in South America, Africa, and South Europe, southern Asia, and Australasia. They form two sections, of which one, *Rhinolophi*, are peculiar to the Old World; and the other, *Phyllostomata*, to the New World. The *Gymnorhinæ* have nearly the same distribution as the leaf-nosed bats; but they range somewhat farther north. In connection with this, we find that there is a closer alliance between the faunas of an area of given size belonging to the bats without nose leaves, than between those which have nasal appendages. Thus, there is no genus of leaf-bearing bats common to the Old and New World; whereas several genera, and some species, belonging to other families, are found both in America and Europe.

The *Hystricidæ* are found in North and South America, in Africa, and in southern Asia. The species are most abundant in Brazil, less so in other parts of South America, still less so in Central and North America, and still less in Africa and Asia. Very few species have a high northern range. The porcupines, or *Hystricina*, are common to America, Europe, Africa, and Asia. The Old World species are burrowers, and have a different type of structure from their New World allies, which are arboreal in habits, and provided with prehensile tails. The beavers show a remarkable distribution. The extinct species have, as yet, only been obtained from the east coast of the United States, and the west coast of France. The living species have a wide range in North America, and had very recently in Europe. The genus

Lagomys occurs in the Rocky Mountains, and in Central Asia. Its former connection would seem to have been by way of Asia and America; but as fossil species are known in the pliocene beds of Western Europe, there is a possibility that the connecting route was from Europe to North America. The genera *Tamias* and *Spermophilus* extend along the temperate region of Asia, and by Behring's Straits into North America; the species on either side of the strait are distinct, although very similar, and the course of migration seems to have been across the straits themselves, or the land which occupied their site. Caution, however, is required in assuming, without the direct warrant of facts, that these creatures can readily cross the straits, either by water, or by ice, when frozen over. Murray has some remarks on this, which we give here, in order that his views may be rendered clear:—"Dr. Baird says, and I suspect the majority of naturalists would concur in the remark, that 'there is nothing to prevent the mammalia of the north-western portions of the American continent from passing over to Asia, or the strait intervening, when frozen over every winter.' Now, I think we may sometimes stretch this idea too far. It is perfectly true as regards some animals, but I am not sure that it is equally applicable to all. The quotation which I have given from Captain M'Clintock's diary shows that apparently the whole of Polar animal life is migratory, and swarms across the ice as freely as over the land. But I have some difficulty in believing that non-Polar animals would equally avail themselves of the same means of transit. Certainly the fact seems to have been that these *Spermophilæ* do not avail themselves of this yearly bridge, for neither of them extend their range beyond their respective continents, but come up close to the straits—*S. Parryi* being found in the island of Aricamtchitchi at the straits, and the other on the Kamtschatkan shore. If it were not so—if the time when they crossed from one continent to the other was not distant, why are they not absolutely identical? If *S. Parryi* could take a run across to see its cousin, *S. Eversmanni*, every winter, or S. *Eversmanni* in like manner come over to America, why should *all* the American specimens be bigger? and why should they all, and always, have shorter and bushier tails? Some distinctive difference occurs in every species with which I am acquainted, which is represented both in North America and the Old World. There is constantly a perceptible distinction, although it be slight. On this ground, it seems to me plain that the journey across Behring's Straits is not a thing which 'there is nothing to prevent.' In one sense (the physical one) there is nothing to prevent it." He goes on to remark that the voyage is one of great hardship and uncertainty to a Spermophile. Several days would be required, no food would be obtainable, and there is no apparent inducement to leave the place where food is, for an unknown locality, to reach which so much danger is braved. The Spermophiles, it should be noticed, are not migratory animals. The *Arvicolinæ*, exclusive of the Lemmings, are spread over the northern hemisphere; but few species occur in high latitudes, nor are any known south of 20° N. lat. The Lemmings range as far north as navigators have attained. The *Muridæ* are exceedingly numerous in species, and have a very wide range. Like some other families, which occur in both the Old and New Worlds, the groups occupying the two areas form natural zoological sections. Those of the Old World have large and broad molars, with transversely situated tubercles; the upper molars have three tubercles in each transverse series. Those of the New World have narrower molars, and only two tubercles in each transverse row. This seems to be the natural arrangement, but it has become somewhat confused in consequence of the facilities which civilization has afforded for the introduction of species from their original area to others which are adapted for them. Thus, the common rat is found everywhere, and in North America it thrives as well as any species. There is no positive record as to when it was taken there, but there is little doubt it has been introduced from Europe by man. Several species of *Mus* have been described as new from South America, which on examination have proved to be varieties of some common European rat; and it is highly probable they have been introduced. If this fact be established, it has an important bearing on geographical distribution, for it shows that when a European rat is transferred to South America, not only may it thrive, but it varies. This variation has taken place since Europeans first crossed the Atlantic. The indigenous forms on either side of this ocean are generically distinct. On the hypothesis, then, of continuous areas, and the evolution of species by variation, it might be said that the varieties have sprung up since the European touched upon the shores of South America; and in like manner, that the present genus *Mus*, and at least one or two others, have originated since the *Muridæ* on one side of the Atlantic ceased to communicate with their allies on the other. The cessation of communication possibly coincided in time with the separation of Europe from America. The South American *Muridæ* are for the most part distinct from those of North America, no species, we believe, being common, and but few genera. The species, however, of the genera which are common, usually arrange themselves into two groups, one of which is found in the north and the other in the south. The differences seem to show that at some former time North America was separated from South America. As illustrations we give Murray's remarks on *Hesperomys* and *Reithrodon*. The range of the former genus, he says, is seldom laid down correctly in physical atlases. "It is found over the whole of the continent, both of North and South America; but the South American species all differ a little from the North American; and not only so, but none of the subsections into which they have been divided are found in both. Three out of several subgenera, originally suggested by Waterhouse, have been adopted for the South American species; and Baird has made three more for the North American. The differences on which they are founded are, however, all slight in degree, and do not correspond with any geographical limits, the species being mingled with each other, except that the South American sub-genera, taken as a body, are slightly different in type from the North American, and are for the most part larger in size. Allowing for exceptions in both countries, they can be best characterized by saying that the South American species are all rats, and the North American all mice, there being only one North American species of any size, and it not exceeding the dimensions of a half-grown Norway rat." The genus *Reithrodon* was founded by Waterhouse for some species like *Hesperomys*, which were of large size and possessed grooved incisors. They were obtained from Patagonia. Subsequently some small species having a similar character were found in North America, and were also referred to Waterhouse's genus. The species of the south, however, differ in other points from those of the north. Thus, as Murray remarks, "the South American *Reithrodons* have a body six inches in length, so stout and so full, and the head so large and much arched, that one species has been called *R. cuniculoides* (rabbit-like). The tail also does not exceed half of the body. The North American species, on the contrary, are the smallest of the mice, scarcely more than half the size of the house-mouse, which they otherwise closely resemble in shape and proportion. The tail is as long as the body alone, or else longer than the head and body together. The shape and size of the skull are quite different. Until the species of the South American *Reithrodon* be compared with the North American, it is premature, therefore, to treat them as identical. To do so may lead to misapprehension of their affinities and geographical distribution. I, therefore, in the meantime speak of the two as the South American *Reithrodon*, and the North American *Reithrodon*. Three species of the South American genus are known, one inhabiting the open grassy savannahs of Maldonado, another the coast of Patagonia, and the third the straits of Magellan. The North American genus contains four or five species, which are confined on the Atlantic border to the Southern states. They are found about St. Louis and westward to the Rocky Mountains. Species occur also in New Mexico, Sonora, and California. We have already seen that there are grounds for believing that the break between North and South America, which at some former time must have existed, probably did not occur to the north of Guatemala, but between it and New Grenada. The distribution of *Hesperomys* and of the *Reithrodons* confirms this view." The Old World genus, *Mus*, comprises a host of species, of which a few have now an almost cosmopolitan distribution. All these there is little doubt are really indigenous to the Old World; but they so readily find the conditions suitable for them that it is a difficult question to decide where their original home is. Thus, the brown rat is now to all intents and purposes a true European species, but it has only recently become such. The Greeks and Romans do not seem to have known it. It is believed to have come from Asia into Europe in the 17th or 18th century; in 1775 it was taken to North America; before the termination of the century it had found its way to Brazil; and in the present century it has established itself in California. Audubon and Bachman say it was not to be found on the Pacific coast in 1851, but since then, and apparently coincidently with the extension of the Californian gold-diggings, it has become as plentiful there as in western Europe. The black rat seems to have preceded the brown in most areas, and to have afterwards succumbed to it. Little is known as to the history of its extension in Europe, but in some countries, England amongst them, the black rat is now rare, and the brown very common. It appeared in North America very soon after that country was discovered, spread everywhere, and will probably be decimated by the brown species. It also made its appearance in New Zealand soon after European vessels began to visit that island; it has since overrun the island, and nearly exterminated an indigenous species of *Mus*. The Norway rat has arrived there since 1843, and is pushing its way vigorously to the disadvantage of its ally. This constant succession of the black by the brown rat is very remarkable, and may have an important bearing upon various inquiries. Thus, a rat has been found in one of the Gallapagos islands which is evidently of the Old World type, and is, moreover, very similar to the black rat. Views may differ as to its affinity; some may consider it a variety of the black, and others, with Mr. Waterhouse, who calls it *Mus Jacobiæ*, a distinct species therefrom. "If a new species," says Murray, "it is one which has been made within a few generations. We can almost specify the date since which it has been made. Being of the black rat kind it must have been established on the island previous to the supremacy of the brown rat, that is, before the latter had become the common kind in ships and houses." It appears that the Gallapagos islands were visited about 150 years ago by buccaneers, and hence it appears probable that the conditions here prevalent have sufficed to evolve a species in less than two centuries. How long then, it may be asked, will it be before a species allied in like way to the brown rat will be discovered? The settlement of this question would be much facilitated if a list of extra-European localities where the brown rat is now found were compiled, careful and minute descriptions were drawn up of the brown rats of each locality, and naturalists were to notice from time to time what changes could be detected. We can refer to one such species, but exception may be taken to the locality as not allowing one to ascertain the date of introduction. We allude to *Mus alexandrinus* of Egypt.

This species, or reputed species, has been the subject of an elaborate inquiry by M. De l'Isle. He found that *Mus rattus* and *Mus alexandrinus* absolutely agreed in anatomical structure and in habits, the only difference being in colour. He ascertained that the extreme types of coloration are connected by a series of intermediate forms, and considers that as *M. alexandrinus* possesses the prevalent colour of the genus, it is the parent stock rather than a descendant of *Mus rattus*. He obtained hybrids between the two forms, and reared several generations from these without perceiving any signs of decrease in the power of reproduction; he also succeeded in obtaining a black rat from the union of two pure Alexandrine rats. He believes Arabia was its centre of creation, that it was imported into France at the end of the 12th century with the light-coloured fur of *Mus alexandrinus;* and that in three centuries, during which about 900 generations had existed, it acquired its dark tint. If all the species of *Mus* were subjected to the same searching scrutiny we should be able to form a much clearer idea of the past and present distribution of this widespread type than we have now.

The living marsupials occupy two areas which could not well be more distant and more isolated one from the other; the first is Australia, and the islands immediately to the north of it; while the second is America, between the latitudes 40° north and south. The greater number of the genera are exclusively Australian. The opossum is one large group which is not represented in Australia. Its stronghold is Brazil, where 22 out of 32 species are found. The remainder are scattered through Chili, Peru, Paraguay, Guiana, Mexico, California, and the eastern United States. The opossums are widely separated from their allies of Australia, and it is a question in what way the faunas of the two areas have been formerly united. Some have suggested that it was land connecting America with Australia; but considering that extinct marsupials have flourished in the northern hemisphere, it is not impossible that the land connection may have been by a more northern or circuitous course. In this question the relative affinities of the species will afford considerable help. If the Australian forms are more nearly allied to those of America than to any that occurred on other areas, and have become extinct, there is a probability of a direct land connection between South America and Australia; but if they are more nearly related in structure to the extinct forms of Europe, the probability is that they were derived from Europe. But the marsupials have existed for so long a time, since they commenced existence at least as far back as the oolitic period, that it may well have happened that migrations have occurred in many different directions, and across many different lands. At present the nearest species allied to the opossums from other areas than South America is supposed to be the *Didelphys Cuvieri* from the eocene beds of Paris. We need not detail the distribution of each Australian genus, but will append Mr. Murray's summary of inferences drawn from the facts supplied by them. The first is "that the north [of Australia] is thoroughly isolated and distinct from the rest of the continent. With the solitary exception of *Phalangista vulpina*, which may have reached it by overland migration, not a single species inhabits it which is known elsewhere. At the same time, unlike the south-west, it has no unknown type of life. It has merely a collection of new species of genera already well known as inhabiting New South Wales, although most of them are so distinct as to indicate a long period of separation, only one (*Petaurus ariel*) besides the *Phalangista* being near any of the New South Wales species. Next, it appears plain that the south-west corner, viz., that part of the continent stretching from Sharks Bay southwards, and round past Perth and Swan River, is a peculiar district. This, although possessing fewer endemic species than the north, has more of special organization. Here have been found those species of which no other similar creature has been found in any other part of the world. As to actually distinct species, although not distinct forms, we find 28 species out of 39 (that is, about three-fourths) peculiar to itself. Four are common to it and the country to the north of it (North-West Australia), but are not found in South Australia, with which, however, it shares six. The difference between it and North Australia seems to be this, that although both equally isolated at some former period, the one (the south-west) has been so at a more ancient date, and for a longer period; and when the space between was raised out of the sea, and the intermediate regions turned into dry land, the character of the district surrounding North Australia has been of a more desolate, inhospitable character than that between South-West Australia and New South Wales, the communication between which, although difficult, has not been impracticable, as seems to have been the case with the north; from which it may perhaps be inferred that the north has been last raised, and that the upheaved bottom of the sea to the south is more desolate from having had less time to become clothed with a productive soil. New South Wales stands nearly in the same position as South-West Australia, as an isolated region. It has forty species, of which twenty-nine are peculiar (or forty-one out of sixty, if Van Diemen's Land be taken along with it). Eleven of these are found in South Australia, and five in West Australia. Van Diemen's Land, although belonging to the same division of the continent as New South Wales, has an unusually large number of endemic species. Out of twenty species, twelve (that is, rather more than half) are peculiar to itself, and amongst them are more of the marsupial carnivora than are found in any other part of the continent, one of them being the *Thylacinus*, which is a peculiar type found nowhere else. The general strain, however, of the species found in Van Diemen's Land is that of New South Wales. They are, with the exception of the *Thylacinus*, all species of genera also existing in that region. Notwithstanding its large proportion of endemic species, therefore, it is not entitled to be regarded as a distinct and independent zoological province in the same sense, or at least in the same degree, that the north and south-west are, nor does their disproportion tell us anything about the length of time for which Van Diemen's Land has been separated from the mainland. I have already explained that I do not think time has anything to do with the increase of species, except as giving greater opportunities for the occurrence of physical changes in the conditions of life, through which change in species may be induced. Lastly, South Australia has twenty-eight species, of which only four, or one-seventh (the smallest proportion of any) are peculiar. It has thirteen in common with New South Wales, and the same number common to Western Australia, and of these there are five common to all three. Only two are common to the south-west corner. It has obviously little claim to be considered a zoological province. It is the mere highway between the east and the west, as it was formerly the ditch or barrier separating them. The country between North and South-West Australia is chiefly indebted for its inhabitants to the countries bordering it to the south and east. The number of species as yet found in it is thirty-three. Of these ten, or about one-third or one-fourth, are endemic. The rest have found their way from the south-west, or from New South Wales."

The *Monotremata* is a very small group combining three species of remarkable structure, all of which are confined to Van Diemen's Land, New South Wales, and South Australia.

From the above statements it may be conjectured in what way Murray would divide the world into four great mammalian regions. They are (1) the Europæo-Asiatic; (2) the Africano-Indian; (3) the Australian; and (4) the American. The first nearly corresponds with Sclater's Palæarctic region, founded upon the distribution of birds; but he carries its southern boundary to the southern edge of the Sahara desert. He does this on the ground that the Saharan fauna, although it contains many peculiar species, has evidently been derived from the north, not from the south. The Africano-Indian region consists of Africa south of the Sahara desert, South Arabia, India, the Malay Peninsula and Archipelago, and China. This differs from Sclater's arrangement in that it amalgamates the Indian and Æthiopian regions. Murray recognises that these have distinct faunas, but in the case of mammals the difference is of far less extent than between the principal regions. Many features which they have in common have been pointed out. Murray makes three subdivisions or sub-regions. The Australian region is nearly the same as Sclater's division bearing a similar name. The American region is another instance in which Murray regards as one region what Sclater makes two. The extreme north is regarded as a subdivision of the first region; the remainder of the continent belongs to the fourth, and is divisible into a northern and a southern moiety. The Old World forms, it is thought, passed over into North America from Asia, not from Europe.

The geographical distribution of animals may be studied from several points of view; thus attention may be confined to the distribution of each natural group, or to the relative proportions of such groups in each area, or to the distribution of characters. Examples of the first mode have been given; and we now come to the third, which, however, some persons do not consider as appertaining to the subject we are dealing with. It is not an unusual thing for most of the animals in one region to be different specifically from those of another. The true specific differences vary in nature and degree for each genus; but there are other differences, which of themselves do not seem to be of specific value, which are common to most of the species on the same area. These nearly always belong to external parts. For example, nearly all the species found in the Sahara desert or in the great barren plains of Asia (which, with the desert, form a long broad band across the land), have a sandy colour, large external ears, and remarkable powers of sight, hearing, and smelling. These characters, in their intensified degree, seem to be related to, and not merely coincident with, the habitat. In the case of the fauna of the Sahara desert, M. Pucheran observes that the researches of geologists have proved that at a period not long distant it was an arm of the Mediterranean Sea. If so, the fauna must have migrated to the area since the sea has diminished and disappeared. Were the species expressly created for and adapted to the region? He believes not, and having that belief he asks whence it came. The region which contains more of its species than any other is Abyssinia, and hence he concludes this country was their starting point. The genera are nearly all European, so that the course of migration was in part from Europe, and through Abyssinia. He considers that the peculiar features we have referred to have been acquired since the fauna established itself. He comes to similar conclusions respecting the fauna of the Asiatic deserts, pointing out the evidence which indicates that they were once under water, and that the species are nearly related to those of contiguous regions.

Nearly all the Algerian species of birds and mammals belong to European genera, a fact which harmonises with the view that since the present genera have been established, Algeria was connected with Europe, and separated from South Africa by the Sahara sea. These species, however, differ from their congeners in one point, viz., that they are nearly always smaller. Pucheran thinks this has been induced or acquired since Algeria was separated from Europe by the Mediterranean. They also differ in a second point, viz., in having shorter hair, in which respect they also differ from South African mammals.

Again, it generally happens that when a genus is represented in Mexico and North America, the northern species have the thicker and smoother hair, and this character also obtains in those species which live to the south of Mexico. The *Felidæ* of South America generally have spotted skins; but spots are rarely, if ever, observable on their congeners in North America. M. Pucheran argues that these regional faunal characters have been acquired during the sojourn of the species in their native districts, that this is closely connected with the circumstance that Central America was at a not very distant geological period under water, and that its mammalian fauna differs in the point mentioned from those north and south of it.

New Guinea possesses representatives of 21 genera of birds; and there are certain characters common to all, viz., strong legs, a well formed first toe terminated by a curved claw, digits of equal length and also provided with curved claws. These characters especially adapt the species for perching; and since they are so universal, one infers that forests abound and plains are rare. The few mammals known also have certain characters common to all, which eminently adapt them for arboreal life. This again implies that New Guinea has long been a region of forests. Even the Kangaroos, which, as a family, are usually jumpers on the ground, are here tree-climbers. The inference that the country inhabited by this fauna is, or has very recently been, almost entirely covered by trees, might be made upon the evidence of these characters only; but we know that New Guinea is what Wallace has described it, viz., a vast, even, verdant forest. But if a similar set of characters were to be found in an extinct fauna, we should be justified in saying that the land they lived in was a forest land.

The facts which have been above stated, and the ideas which have been thrown out, cannot fail to have convinced the reader how intimately associated geology is with the geographical distribution of animals, and how the one is calculated to advance our knowledge of the other. It would seem that the greatest uniformity in the fauna occurs in those lands which have been longest connected, that the influx of new species is most active immediately after the separation of a continent into two or more parts isolated from one another; and that the fauna of each district frequently has some generally distributed external character or characters, which characters are superinduced by climate or orographical conditions. It seems probable that the longer the lands have been isolated the more widely do their faunas differ. These hypothetical conclusions are based upon the living creation; but, if true, we ought to perceive similar phenomena amongst the beings that have passed away. If palæontology were pursued in this spirit, we believe that it would be possible to conjecture, with a very near approach to the truth, the various directions in which faunas have travelled, the approximate periods they have been isolated, the various regions which those isolated faunas have occupied, and the relative eras when two faunas have amalgamated by the junction of their areas. Doubtless the changes have been very complex, but, as everywhere else in creation, some guiding laws will be discoverable, and the deductions of the palæontologists may receive important aids from the correlative testimony which geologists ought to be able to afford. On the other hand, the student of the geographical distribution of animals, whether of the present or of past time, can indicate many fruitful lines of inquiry which the geologist might follow up. To take one case. The vertebrates of South America are remarkably restricted in their range, very few species occurring throughout its whole extent, even on the east side of the Andes. In Africa, on the other hand, a great number of species are to be found from the Cape of Good Hope on the south to the Sahara desert, and Nubia on the north. This might be explained by supposing that Africa has never been split up into isolated districts since the present species, and many of the present genera of all classes of terrestrial vertebrates, have been established. Perhaps there is reason to carry its continuity still farther back, and there may be zoological evidence to support Sir R. I. Murchison's opinion that Africa has been dry land since the secondary period. America, we should conjecture, has been recently split up into isolated districts, a view which it is for geologists to disprove or confirm. (Hoeven, J. van, *Philosophia Zoologica*, 1864; D'Archiac, *Géologie et Paléontologie*, 2^e Partie; Murray, *Geographical Distribution of Mammals;* Pucheran, *Revue et Magasin de Zoologie*, 2^e Série, volumes for 1865, 1866, 1867.)

GEOLOGY. [See the following headings in E. C. S.:—Boulders; Boulder Formation; Carboniferous System; Devonian Group; Chalk Formation; Laurentian Formation; Quebec Group; Post-Pliocene; Eocene; Old Red Sandstone; Taconic System; Silurian System; Cumbrian Rocks; Cambrian Rocks; Caves; Kames; Glaciers.]

GERSDORFFITE. This mineral species has been referred to under Amoibite and Nickel, E. C., being called Nickel-Glanz in the latter place. It is a sulpharsenite of nickel (Ni_2 S. As) in which the nickel may be replaced isomorphously in small quantities by iron or cobalt. It crystallises in cubes, and presents the same variety of form as is met with in Cobaltine, which is a sulpharsenite of cobalt. At Loos it accompanies several cobaltiferous ores. It is also found at Schladning, Styria; Prakendorf, Hungary; Lohenstein, Voigtland; Taune and Harzgerode in the Harz; and near Siegen, Westphalia. The *Tombazite* of Breithaupt and the *Amoibite* of Kobell are probably varieties.

GLACIERS [E. C. vol. ii., cols. 1031—1035.] The investigation of the phenomena of glaciers has been as active during the last ten years as in almost any preceding decade, as is evidenced by the numerous eminent men who have recently devoted more or less of their attention to them. Agassiz still labours on, although he has transferred his researches to another field, and is as bold as ever in his speculations, as witness his hypothesis of a great glacier stretching across the valley of the Amazon, a glacier which must have been a worthy rival to the Rhone glacier which transported the Alpine blocks on to the Jura Mountains. Professor J. Forbes and Mr. Hopkins have been taken from us; but Tyndall, Ramsay, Murchison, Godwin-Austen, Haast, Hector, Mortillet, Lecoq, Sars, Kjerulf, Omboni, Dollfuss-Ausset, Lory, Desor, Martins, Rink, Frankland, Croll, Dove, and many others, have done much to advance our knowledge on the subject.

A glacier is a most impressive object, and although at one time regarded as an emblem of rigidity and permanence, it is known to be no more "everlasting" than the hills. It is in constant motion, day and night, summer and winter; it flows slowly from the regions of snow, but its particles vary in their rate of motion according to the accidents of position and season. In some respects it behaves like a fluid, while in others it comports itself like a solid. Thus it resembles a river in conforming to the shape of its bed, contracting and deepening where the gorge is narrow, and spreading out again where the valley widens out; while like a rock it is faulted, stratified, and cleaved. On all these points, and many others, we shall say more or less in the sequel.

What are the causes which produce glaciers? Such a question is more easily asked than answered; for of the many conditions which might have operated, it is difficult to say which amongst them have prevailed in evolving any given set of glaciers. In all cases glaciers are subsidiary to, and dependent on, vast accumulations of snow. The size of the glaciers is regulated by the extent and thickness of the snow-field, the configuration of the land, the circumstances which promote the conversion of snow into ice, and the rates of motion and dissolution of the glacier itself. The quantity of snow is governed by the climate, and this again is a sequent of the distribution of the land and water, the direction of aërial and oceanic currents, &c. From this it will be seen how ramified the subject is, and how closely the history of a glacier may be connected with what is going on in lands far distant, and with what has taken place in ages long gone by. It is the case, however, with glaciers, as with all natural phenomena, that they are not isolated, but are more or less connected with what has been, with what is, and with what is to be. So varied are the possible causes, that one hardly knows how to decide which really operated. In the case of Europe, however, we know that glaciers were far more abundant than at present, and that what is to be seen now is a relic only of the great ice spread which covered the country at a very recent geological epoch, hence called the glacial epoch. The evidence of physical geography, zoology, and botany renders it almost certain that the greater prevalence of ice during the glacial period was mainly due to, or at any rate coincident with, a colder climate. This we consider to be an important point, if established, in relation to hypotheses respecting glaciers.

Snow is one of the results of the great distillery of nature; the ocean being the fountain-head or evaporating vessel, the cold air the condenser, and, in the case of snow, the coldest portions of the earth's surface the reservoir. Those conditions which enable the largest quantity of water to be carried from the ocean to the coldest, most extended, and least uneven areas, will form the largest snow-fields. The result, then, depends upon the size of the ocean, upon the rate at which the water is evaporated, upon the direction, temperature, humidity, and electrical condition of the winds which pass over the ocean, upon the extent of the air-current superficially and vertically, and upon the completeness with which the moisture is converted into snow. The next step is the conversion of the snow into ice, and here also there are many circumstances to be taken into account, for the size of the glacier partially depends upon how much of the snow becomes ice. The last step is the liquefaction of the ice, during which the glacier is evaporating; so that its size is more or less regulated by the ratio between its velocity and its rate of dissolution and vaporization.

The deposition of snow is so much the result of climate that to discuss the conditions which tend to increase or diminish a snow-field would require the introduction of many details of meteorology, hydrography, and physical geography, which would seem out of place here. We may refer to one remarkable set of phenomena. All substances are constantly interchanging heat with one another by radiation. If they give out more than they receive they are cooled, but are warmed if they receive more than is lost. The sun sends down heat accompanied by light, which heat may be designated as luminous; this is partially reflected, and partially absorbed by the earth. The absorbed caloric is again parted with as obscure or non-luminous radiant heat, which passes into space. These two kinds of radiant heat differ from one another in the facility with which they penetrate substances, for it often happens that the luminous heat will traverse what radiant heat cannot. Thus glass will allow the luminous heat to pass through it, but it almost completely stops the dull heat from a furnace. Water acts in the same way. It is transparent (or, if one may coin a new word more adapted to the sense, transpiercent) to the sun's heat, but intercipient to that which is radiated from the earth. As substances are warmed by radiant, but not by transmitted heat, it is clear that wherever there is dry air above and moist air below we have an arrangement by which the sun's heat is accumulated more in the lower than in the higher regions of the air. The more concentrated the humidity is in the lower portions of air, the sooner is the heat cut off, and the colder is the air at a given level. The coldness of a mountain area is, then, influenced by the humidity of the lower atmosphere not only in its vicinity, but wherever the snow-bearing current has been, and by the degree of prevalence of upward currents, which convey the heat from below to above by convection. It is usually stated that the cold of the upper atmosphere is due to the rarity of the atmosphere, but this is an insufficient explanation. There is something more, viz., that when air expands it consumes heat, which heat partly performs mechanical work in moving the particles and resisting the external pressure which opposes the expansion. When the air ascends it expands because there is less pressure, and if very high up it cannot acquire more heat. Hence the heat which it possesses is more dispersed, and consequently less concentrated. In fact, the air is colder. Tyndall's view is different from this, as will be seen presently. In addition to this, the elevated air can get rid of its heat more readily by radiation, because there is no veil of moisture between it and the cold of space. As these views are important, we will quote some remarks by Tyndall bearing upon them, notwithstanding that they substantially repeat much that is said above:—"It is probable that, were the earth unfurnished with this atmospheric swathing, its conditions of temperature would be such as to render it uninhabitable by man; and it is also probable that a suitable atmosphere enveloping the most distant planet might render it, as regards temperature, perfectly habitable. . . . . . Where radiant heat is allowed to fall upon an absorbing substance, a certain thickness of the latter is always necessary for the absorption. Supposing we place a thin film of glass before a source of heat, a certain percentage of heat will pass through the glass, and the remainder will be absorbed. Let the transmitted portion fall upon a second film similar to the first, a smaller per-centage than before will be absorbed. A third plate would absorb still less; a fourth still less; and after having passed through a sufficient number of layers, the heat would be so *sifted* that all the rays capable of being absorbed by glass would be abstracted from it. Suppose all these films to be placed together, so as to form a single thick plate of glass, it is evident that the plate must act upon heat which falls upon it in such a manner that the major portion is absorbed *near the surface at which the heat enters*. This has been completely verified by experiment. Applying this to the heat radiated from the earth, it is manifest that the greatest quantity of this heat will be absorbed by the lowest atmospheric strata. And here we find ourselves brought, by considerations apparently remote, face to face with the fact (? *a* fact) upon which the existence of all glaciers depends, namely, the comparative coldness of the upper regions of the atmosphere. The sun's rays can pass in a great measure through these regions without heating them, and the earth's rays, which they might absorb, hardly reach them at all, but are intercepted by the lower portions of the atmosphere. Another cause of the greater coldness of the higher atmosphere is the expansion of the denser air of the lower strata when it ascends. The dense air makes room for itself by pushing back the lighter and less elastic air which surrounds it ; *it does work,* and to perform this work a certain amount of heat must be consumed. It is the consumption of this heat—its utter annihilation as heat—that chills the expanded air, and to this action a share of the coldness of the higher air must undoubtedly be ascribed. A third cause of the difference of temperature is the large amount of heat communicated, *by way of contact,* to the air of the earth's surface ; and a fourth and final cause is the loss endured by the highest strata through radiation into space." The point in which we differ from Professor Tyndall is as to the cooling effect of expanded air. It seems to us that if the denser air is so charged with heat that it can rush through the rare air, it must have a store more than sufficient to allow it to expand without a general diminution of temperature. No question, heat is consumed in performing work, and the expanded air is thereby cooled. But even then we imagine it must be much warmer than the cold air amidst which it has introduced itself. Such air, we think, would raise rather than reduce the temperature.

The snow which falls in localities where the temperature is much below the freezing point of water is pulverulent and dry. In this condition the particles refuse to adhere or cohere together, so that it is impracticable to form them into a compact mass, such as a snowball ; and so long as they retain this condition they cannot be converted into ice by ordinary agents. It is only when the temperature approaches 32° F., and when the snow becomes moist, that those coherent powers come into play which allow of the snow crystals to weld together into a mass. It would be possible for a snow-field to exist without giving rise to glaciers. Such a phenomenon would happen if no part of the snow-field ever attained a temperature higher than 0° F., and if the area on which it rested was entirely bounded by perpendicular precipices, which descended to beneath the snow line. The surplus snow would fall, or be blown over the cliffs. If there were few slopes between the snow-field and snow line, the glaciers would be small, however favourable all the other conditions might be. The nature of the slopes, then, has an important modifying influence. The snow is partially got rid of by evaporation, and partly by falling and being pushed down the slopes. The first step towards the formation of ice is the melting of some of the snow under the action of the sun. The superficial water is carried downwards, and is soon frozen again. In this way the granules are cemented together, and the interspaces are filled with air. The solidification of the mass goes on more rapidly, up to a certain point, the longer and higher the melting temperature is continued. In this way the rotten, porous, opaque icy zone, called *névé*, is originated; but before it can become true glacier ice, it must be compressed when at about a temperature of 32°. This pressure, if applied slowly, will expel the air bubbles, which are the cause of the opacity, and enable the granules to amalgamate into a solid, transparent mass of ice. This ice, it should be noticed, is not simply compressed snow, nor is it frozen snow and water, but it is snow and ice, which have been pressed at a temperature a little below 32°. Many of the phenomena of a glacier depend upon the circumstance that the ice is near its melting point, and that it then possesses certain properties which are not apparent when it is much colder. The most prominent of these is the property of contracting perfect cohesion, which was called regelation by Faraday and Tyndall. Faraday showed that when two pieces of moist ice were brought into contact they were cemented together, but no cementation occurred when the ice was dry, and below 32°. The union takes place in water, even if its temperature be as hot as the hand can bear. It would seem that the liquid film between the two lumps of ice freezes whenever it has contact with the ice only; and also that the union is not merely a sticking together, but a perfect rapid fusion and welding together. Tyndall soon applied the fact to glaciers. He demonstrated that the moist ice might be moulded into any form by gradual pressure, and that a crushed slab might be welded or regelated into a perfect solid. Exception has been taken to the term regelation, as implying that the ice is melted, and then refrozen ; but, as we understand it, this appears to be the case, and the term is by no means inappropriate. There are two solid masses separated by a liquid film. If union was effected simply by the solidification of this film, there would be gelation only, and the connection analogous to pieces of paper gummed together. There is something more than this. The original surfaces appear to be fused and refrozen ; and it is this act which constitutes the peculiarity of regelation. Pressure is not essential, since regelation takes place between two pieces of ice which are held together, without pressing, in a vacuum; although pressure facilitates the process by bringing the surfaces in contact. So readily is the ice moulded, that in flowing down valleys it readily conforms to their shape, and behaves to a considerable extent like tar, or treacle. Hence Forbes founded upon this his viscous theory. But this only proves the plasticity of ice ; and in order to be regarded as viscous, it should be tough, and capable of being drawn out into threads ; whereas it is brittle, and almost without any tensile property.

The white colour of snow is caused by its mixture with air; but its real colour appears to be blue, like that of ice itself. This is connected with the action of water in all its forms of absorbing the rays of heat and light which have the slowest undulations, or those which form the red end of the spectrum. When freshly-fallen, snow emits a beautiful blue tint wherever a hole is made. Tyndall observed this on several occasions. Thus he states that when he visited the Mer de Glace in 1859 he frequently examined the colour of the snow: "though fresh, its blue tint was by no means so pronounced as I have seen it on other occasions; still it was beautiful. The colour is, no doubt, due to the optical reverberations which occur within a fissure or cavity formed in the snow. The light is sent from side to side, each time plunging a little way into the mass; and being ejected from it by reflection, it thus undergoes a sifting process, and finally reaches the eye as blue light. The presence of any object which cuts off this cross-fire of the light destroys the colour. I made conical apertures in the snow, in some cases three feet deep, a foot wide at the mouth, and tapering down to the width of my baton. When the latter was placed along the axis of such a cone, the blue light which had previously filled the cavity disappeared; on the withdrawal of the baton it was followed by the light, and thus by moving the staff up and down its motions were followed by the alternate appearance and extinction of the light. I have said that the holes made in the snow seem filled with a blue light, and it certainly appeared as if the air contained in the cavities had itself been coloured, and thereby rendered visible, the vision plunging into it as into a blue medium. Another fact is perhaps worth notice: snow rarely lies so smooth as not to present little asperities at its surface,—little ridges or hillocks, with little hollows between them. Such small hollows resemble in some degree the cavities which I made in the snow, and from them, in the present instance, a delicate light was sent to the eye, faintly tinted with the pure blue of the snow crystals. In comparison with the spots thus illuminated, the little protuberances were grey. The portions most exposed to the light seemed least illuminated, and their defect in this respect made them appear as if a light brown dust had been strewn over them." Water, which is remarkable for its intercipient power towards radiant heat and the extra or red rays of the spectrum, is blue. Ice, which stops radiant heat better than any other transparent solid, also has a blue tint, but if it contains many air-bubbles, the blue is dull and whitish. The blue colour of the sky appears to be due to aqueous vapour; but in this instance the colour is *reflected* and not *transmitted* light. Air itself is not known to have colour; but from the researches of Brücke it seems probable that the blue of the sky results from the reflection of light from minute particles of aqueous vapour dispersed through the atmosphere; and that the tint depends not so much upon the nature as upon the size and number of the particles. A blue colour is frequently well marked in the waters which have flowed from the largest glaciers into a lake, and is probably caused by suspended particles. The matter is so minutely divided, that Tyndall suggests that the particles in the Lake of Geneva have been ground from the rocks by the glacier, and are the finest thus produced. He refers to the slowness with which some gold precipitants sink in a fluid at rest, viz., a few inches only in several months, and says, "in all probability it would require *ages* of calm subsidence to bring *all* the particles which the Lake of Geneva contains to its bottom."

We next proceed to notice some of the facts relating to the motion of glaciers, and to the hypotheses which have been started in explanation of the cause or causes of such motion. That a glacier moves nobody now disputes, and the fact has been long recognised by the mountaineers. But there has been much controversy as to the rate of the motion. Hugi built a cabin upon the glacier of the Aar. It commenced its journey in 1827, and observations were made on its change of position up to 1841: At the end of the third year it was about 110 yards from its first position ; at the end of the ninth year about 785 yards, and in the fourteenth year about 1570 yards. This would give an average of 112 yards per year, but it will be seen that the rate was constantly increasing. In the first three years the average was 37 yards per annum; in the next nine it was 75 yards, and in the last five 157 yards. In order to draw any conclusion, one requires to know the slope of the bed, and the breadth of the valley. In 1842 both Agassiz and Forbes made accurate measurements and ascertained that the central portion of the glacier moved faster than the sides. Forbes also showed that the bottom moved more slowly than the top; that while different glaciers had different velocities, the speed of each was dependent on the temperature, being greatest in the summer months and least in the winter. He noticed that so long as the temperature was below 32° F. the motion was nearly uniform whatever might be the daily fluctuation, but that when the temperature varied above 32° F. the motion of the glacier also varied. Nevertheless, the annual motion of the glacier was nearly uniform. In the years 1857, 1858, 1859, Tyndall carried on a series of measurements, and confirmed many of the facts reported by Forbes and Agassiz. In addition, Tyndall showed that the true line of maximum speed was not down the centre in the curved portion of the glaciers, but that it arched over from side to side in curves which might be described as exaggerations of those of the bounding valley. A precisely similar thing occurs in rivers. Wherever the water rounds a curve the axis of greatest speed is thrown nearer to the opposite bank. This is indicated in almost every river. For the deeps are on the concave side of a bend, and the shallows on the convex. The shallows are due to the retardation of the stream and silting up of the shore, while in the deeps the water runs so fast that the sediment is not allowed to settle. At the Mer de Glace several tributary glaciers are merged into one, and forced through a narrow gorge. For example, the Glacier du Géant, just before the union, is 1134 yards wide; the Glacier de Léchaud, 825 yards; and the Talèfre tributary 638 yards; the aggregate being 2597 yards. At Trelaporte they are forced through a channel 893 yards wide, which contracts to 863 yards lower down. The maximum velocity of the Géant Glacier was 13 inches per day in July, and that of Léchaud 9½ inches. At Trelaporte the maximum velocity is increased to 20 inches daily, and in the narrow space below to 23 inches per day. In this respect the glacier resembles a river. Forbes' measurements, which prove that the top of a glacier flows faster than the bottom, were made on the terminal face. Tyndall's were executed on the vertical precipice bordering the lateral moraine; and in order to show the difficulties under which some inquiries are prosecuted, and the enthusiasm of some scientific men, we give his account of the operation. "An attempt had already been made, but unfortunately," says our author, "some uncertainty attached itself to the result, due to the difficulty of fixing the lower stake. The guide's attention had been divided between his work and his safety, and he had to retreat more than a dozen times from the falling boulders and debris. I, on the other hand, was unwilling to accept an observation of such importance with a shade of doubt attached to it. Hence arose the desire to measure the motion myself. On the 11th of August I therefore reascended the Tacul, and fixed a stake at the top of the precipice and another at the bottom. While sitting on the old moraine looking at the two pickets, the importance of determining the motion of a point midway between the top and bottom forcibly occurred to me; but, on mentioning it to my guide, he promptly pronounced any attempt of the kind absurd. On scanning the place carefully, however, the value of the observation appeared to me to outweigh the amount of danger. I therefore took my axe, placed a stake and an auger against my breast, buttoned my coat upon them, and cut an oblique stair-case up the wall of ice, until I reached a height of forty feet from the bottom. Here, the position of the stake being determined by Mr. Hirst, who was at the theodolite, I pierced the ice with the auger, drove in the stake, and descended without injury. During the whole operation, however, my guide growled audibly. . . . On Monday morning, the 17th, a dense fog filled the valley of the Mer de Glace. I watched it anxiously. The stakes which we had set at the Tacul had been often in my thoughts, and I wished to make some effort to save the labour and peril incurred in setting them from being lost. I therefore set out, in one of the clear intervals, accompanied by my friend and Simond, determined to measure the motion of the stakes, if possible, or to fix them more firmly, if they still stood. As we passed, however, from L'Angle to the glacier, the fog became so dense and blinding that we halted. At my request, Mr. Hirst returned to the Montanvert; and Simond, leaving the theodolite in the shelter of the rock, accompanied me through the obscurity to the Tacul. We found the topmost stake still stuck by its point in the ice; but the two others had disappeared, and we afterwards discovered their fragments in a snow buttress, which reared itself against the base of the precipice. They had been hit by the falling stones and crushed to pieces. Having thus learned the worst, we descended to the Montanvert amid drenching rain. On the morning of the 18th there was no cloud to be seen anywhere, and the sunlight glistened brightly on the surface of the ice. We ascended to the Tacul. The spontaneous falling of the stones appeared more frequent this morning than I had ever seen it. The sun shone with unmitigated power upon the ice, producing copious liquefaction. The rustle of falling débris was incessant, and at frequent intervals the boulders leaped down the precipice, and rattled with startling energy amid the rocks at its base. I sent Simond to the top to remove the loose stones; he soon appeared and urged the moraine shingle in showers down the precipice, upon a bevelled slope of which some blocks long continued to rest. They were out of the reach of the guide's baton, and he sought to dislodge them by sending other stones upon them. Some of them soon gave way, drawing a train of smaller shingle after them; others required to be hit many times before they yielded, and others refused to be dislodged at all. I then cut my way up the precipice in the manner already described, fixed the stakes, and descended as speedily as possible. We afterwards fixed the bottom stake, and on the 20th the displacements of all these were measured. The spaces passed over by the respective stakes in 24 hours were found to be as follows:—

	Inches.
Top stake	6·00
Middle stake	4·50
Bottom stake	2·56

The height of the precipice was 140·8 feet, but it sloped off at its upper portion. The height of the middle stake above the ground was 35 feet, and of the bottom one 4 feet. It is therefore proved by these measurements that the bottom of the ice wall at the Tacul moves with less than half the velocity of the top; while the displacement of the intermediate stake shows how the velocity gradually increases from the bottom upwards."

Tyndall also made a series of measurements during the winter of 1859, which are more trustworthy than those of Balmat, and more precise than the shrewd inferences of Forbes. He found that near the Montanvert Hotel on the Mer de Glace the sides moved from 6 to 7 inches daily, and that the maximum motion was 15¾ inches. At this same locality the maximum summer motion is 30 inches. At a line 130 yards lower the maximum rate was 17½ inches daily. There is not only a movement down the valley, but also apparently an internal action by which substances in the ice itself are brought to the surface. In July, 1836, a guide went with a visitor from the Montanvert to the Jardin, and carried on his back a knapsack holding a supply of bread, cheese, and wine. The safest route was by a roundabout course, but the shortest was across some dangerously fissured ice. The guide fell down one of the fissures, and the visitor finding himself forsaken amidst a wilderness of ice and rocks, and unable to discover where his guide was, returned to Montanvert. The guide fell to the bottom of the crevasse without suffering much injury. He disembarrassed himself of his knapsack, and reached the surface by the aid of steps cut in the ice with his pocket-knife. The spot where the accident occurred was on the Glacier du Talèfre. In July, 1846, Couttet, the proprietor of Montanvert Hotel, found some fragments of a knapsack, which he recognised as belonging to that lost by the guide of 1836, the knapsack having been his own property. Balmat, a guide, and the guide who lost the knapsack, verified the identification with great positiveness, since both of them had often carried it. The distance over which it had travelled in ten years was 4300 feet, giving an annual rate of 430 feet.

Crevasses are the transverse fissures which occur in all glaciers, and result from the tension to which the ice is necessarily subject, since one part may move three times as fast as another in the same transverse plane; and since the ice possesses little power of retaining its continuity under tension. One point of the ice will move 210 feet in a year, and another, nearer the centre, will have moved over 780 feet in the same space of time. The ice must clearly either stretch or yield; and it does the latter. Although the fissures are numerous, a crevasse is rarely seen in the act of forming. It commences as a mere crack, which gradually enlarges. Tyndall has described a case which came under his observation. A dull sound was heard beneath his feet, as though a heavy blow had been struck against the glacier. Then followed a series of loud reports which seemed to be ubiquitous, in the interval between which a low singing noise could be heard. The glacier was evidently breaking up, and every attempt was made to avoid the threatened danger by running first here, and then there, according to where the sounds came from. The sounds continued for an hour, but no sign of rupture could be discovered. It was then noticed that a stream of air bubbles were rushing through a pool, and this revealed where the crack existed. It was scarcely anywhere wider than the blade of a penknife. The motion of a glacier is tolerably uniform along the central half, so that there is little tension here. The greatest amount of differential motion is at and near the sides, and it is along the sides that most of the crevasses are found; hence these are termed marginal crevasses. The inner ends are always pointed up the glacier, their direction being at right angles to the line of greatest strain. This depends upon the amount of differential motion. There are other crevasses which extend straight across the glacier, and are known as *transverse crevasses*. These are caused by unevenness in the bed of the glacier, such as a ridge, or a sudden alteration in the angle of slope, which strains the ice until its weight overcomes its cohesion, and it snaps. At the Grindelwald glacier the marginal fissures are well developed. The bed of the glacier is undulating and variable in slope, so that the ice is subjected to compression on the more level parts, and to tension where the inclination is greatest. At each ridge there is originated a series of transverse crevasses, but at the bottom of the slope compression squeezes the ice and closes up the crevasses. The transverse crevasses occur in bands separated by unfissured zones; but the lateral crevasses are uniformly distributed. The transverse cracks unite with those of the side, so as to form curved fissures stretching right across the glacier. The convex side of the curves points up the glacier, giving the idea that the sides move faster than the centre, an idea which misled many of the older observers. In addition, there are *longitudinal crevasses*. These occur at the terminal end of those glaciers whose snouts abut against an obstruction, and which have room to expand laterally. When the glacier increases in size, the ice spreads out on either side; but the greater width is gained, not by the mass flattening down, but by the ice yielding in the longitudinal direction or at right angles to the line of tension. In many cases their arrangement is fanlike. These facts have been adduced as proofs of the incorrectness of Forbes' idea of the viscosity of ice. Tyndall calculates that a portion of the Mer de Glace moves with such a differential motion in five hours that the line of particles which at the commencement of the time measured 3224·4 inches becomes 3225·1 at the end. The difference is seven-tenths of an inch. The ice is not sufficiently viscous to stretch this amount, but it breaks and a marginal crevasse is formed. No experiments or facts are known which show whether ice can be stretched at all without yielding. The crevasse which Tyndall saw in the act of forming took several days to attain a width of three inches. Ice is plastic, but not viscous; and, if we mistake not, Forbes regarded viscosity as having the same meaning as plasticity. Thus, in his article on glaciers in the 'Encyclopædia Britannica,' he calls his theory the viscous or plastic, and in a subsequent passage he maintains that ice can be moulded to a surface, in opposition to the then prevailing notion that it was a brittle solid. Professor Tyndall alludes to the great variety of opinion expressed as to what Forbes really meant by his viscous theory. He, selecting some of the substances which Forbes compared to ice, such as treacle, honey, tar, points out that viscidity is, strictly speaking, the term applied to the remarkable tenacity possessed by the bodies, and shows that there is nothing in ice which deserves the name. A perusal of Forbes' work on the theory of glaciers impresses us with the notion that he was striving to demonstrate the plasticity of ice, for all his arguments are directed towards that end, while nowhere does he insist that ice has the tenacity of honey, &c. On the contrary, he appeals to crevasses as the evidence that the ice yields to tension, and argues that wherever they are compressed they unite together. It is true he frequently uses the word viscosity, but he just as often employs plasticity, and frequently both together, as though they were identical. In the main, we believe Forbes' theory is not materially different from the plastic theory as advocated by Tyndall. Forbes was unfortunate in his use of the word viscous, and in some of the illustrations he brought forward, and this, we consider, has led to his having been misunderstood. It would be impracticable to analyse Forbes' book to bear out our statement, but we may quote one passage. The section to which it belongs is headed, "The plastic nature of glacier ice;" then, after some preliminary remarks, he goes on to say that "the viscous nature of glaciers, as deduced from observations by the present writer, though now very generally accepted, had to struggle with numerous and strongly urged objections; of which the oftenest repeated was that ice is by its nature a brittle solid, and not sensibly possessed of any viscous or plastic quality. In answer to this, it may be urged that the qualities of solid bodies of vast size, and acted on by stupendous and long-continued forces, cannot be estimated from experiments on a small scale, especially if short and violent; that sealing-wax, pitch, and other similar bodies, mould themselves with time to the surfaces on which they lie, even at atmospheric temperatures, and whilst they maintain, at the same time, the quality of excessive brittleness under a blow or rapid change of form, that even ice does not pass at once, and *per saltum*, from the solid to the liquid state, but absorbs its latent heat throughout a certain small range of temperature (between 28° 4′ and 32° of Fahrenheit), which is precisely that to which the ice of glaciers is actually exposed; that, after all, a glacier is not a crystalline solid, like ice, tranquilly frozen in a mould, but possesses a peculiar fissured and laminated structure, through which water enters (at least, for a great part of the year) into its intrinsic composition. But waiving the inferences from all these facts, the main argument in favour of the view now maintained is this: that admitting the preceding propositions as to the velocity of its parts (which no one now contests), the quasi-fluid, or viscous motion of the ice of glaciers, is not a theory, but a fact. A substance which is seen to pour itself out of a large basin through a narrow outlet, without losing its continuity,—the different parts of which, from top to bottom, and from side to side, possess distinct, though related velocities,—which moves over slopes inconsistent with the friction between its surface and the ground on which it rests,—which surmounts obstacles, and even if cleft into two streams by a projecting rock, instead of being anchored thereby as a solid would necessarily be, reunites its stream below, and retains no trace of the fissure, leaving the rock an islet in the icy flood,—a substance which moves in such a fashion cannot, in any true sense of the word, be termed a rigid solid, and must be granted to be ductile, viscous, plastic, or semi-fluid; or to possess qualities represented by any of these which we may choose to adopt as least shocking to our ordinary conception of the brittleness of ice!" In a foot note he refers the reader to certain works for a "fuller reply to the objections which have been urged against the plasticity of glaciers." In this passage he is evidently contending that the glacier does not slide down like a solid, but that it flows down like a fluid which possesses a semi-fluid, thick character; and it is clearly in this sense that he uses the word viscous, and not in that which Tyndall assigns to it, viz., gluey tenacity.

It will be seen that in the above passage Forbes says a glacier is not a crystalline solid, like ice. This standing by itself may be true, if by ice be meant ice below 28° F.; but in another place he indicates his meaning by describing a glacier as a mass of ice and water. He alludes to the palpable fact that there is an immense quantity of water engulfed in the ice; but he conceives that it not only fills crevices, but even minute capillary fissures, which extend everywhere through the ice; and it is the hydrostatic pressure thus involved that he believes to be the main moving agent. The correctness of this idea has not been confirmed, and Tyndall adduces facts which militate against it. In December, 1859, there was a long spell of intensely cold weather, which it is imagined must have caused all the water to be drained off from the capillaries, and yet the glacier moved with half its summer rate. In those localities, again, where the superficial supply of water is stopped for the longest period, viz., in the higher portions of the glacier, the winter motion differs but little from that of summer. Experiments have been made with coloured fluids to ascertain whether the ice is traversed by capillaries, but nothing of the kind is perceptible in the sound unweathered ice.

The ice of glaciers does contain spaces of various kinds, some of which contain water and a vacuum, and others water and a bubble of air. The former appear to be the result of a partial decrystallization of the ice, while the latter, it has been suggested, are the original water and air bubbles of the névé which have never been frozen. The former may be produced artificially by converging the rays of the sun to a focus within a block of ice. Along the cone occupied by the luminous rays a number of minute lustrous spots spring into existence, which, when closely examined, are seen to be single or clustered, six-starred or six-petalled figures, with a central bright spot. The moment when the lustrous dots appear is accompanied by a slight clink. What produces the noise? When water is deprived of air and heated in a narrow tube, its temperature may be raised to 300° F. and then it suddenly explodes. When ice freezes, all the air which the water contained is expelled. When the sunbeam passes into the ice a portion of it is melted into water. As such water is perfectly devoid of air, it has a strong cohesive power, and like air-deprived water its cohesion is disrupted suddenly and violently. The water in the ice occupies less space than the ice which it represents, and as it cannot fill the space, the disruption of the particles and the formation of the vacuum is effected with a sudden clink. When a summer sun shines strongly upon a glacier, many persons have heard a remarkable crepitation, which Tyndall has little doubt is due to the formation of myriads of six-rayed figures, each encircling a vacuum. That the bright spots are vacua, not air bubbles, is shown by the sudden collapse of the spaces when the ice is melted. If they were air bubbles they would ascend through the water. In lake ice the figures occur in parallel planes, which mark the planes of freezing. There are no such definite planes in glacier ice; but the various spots occur in all positions. A close examination, however, shows groups arranged in planes parallel to one another, but such planes stand at all angles one to another. It is probable that these really correspond with the lines of cleavage, and, if so, glacier ice is manifestly a composite confused collection of fragments which have been cemented into a compact mass by regelation. The associated air and water cells of glaciers are probably similar to those of lake ice. The last have been examined by Tyndall with a view to ascertaining if they had ever been frozen. He argued that if the air was simply entangled atmospheric air, its density would be at least that of the atmosphere, but if derived from the melting of the water bubble it would be highly rarefied. The ice was placed in warm water, and the action of the air, when brought into contact with the warm water, observed. In all cases the air collapsed, sometimes to a thousandth part of its original volume, a fact which shows a high degree of rarefaction.

In the portions of glaciers about midway between their origin and termination the ice is frequently of a whitish hue, owing to the number of minute air bubbles within it, but traversing the whitish mass are myriads of parallel blue bands, in which the bubbles are absent or rare, and hence the ice has a veiny, streaky, or laminated appearance. Sometimes this structure has a beautiful appearance, and in the glacier of the Rhone it pervades the ice everywhere, while in other glaciers it is less extensive. The different bands vary in hardness and structure, so that when weathered the surface of the ice is worn down into little grooves and ridges, the harder laminæ standing out beyond the softer. The hollows retain all the light dirt which is blown over the glacier, and these dirt lines form useful guides in ascertaining the directions in which the ice has been compressed or squeezed. The veined structure has been noticed by almost every observer of glaciers, but Guyot was perhaps the first who gave a clear description, which we subjoin:—"I saw under my feet the surface of the entire glacier covered with regular furrows from one to two inches wide, hollowed out in a half-snowy mass, and separated by protruding plates of harder and more transparent ice. It was evident that the mass of the glacier here was composed of two sorts of ice—one, that of the furrows, snowy and more easily melted; the other, that of the plates, more perfect, crystalline, glassy, and resistant; and that the unequal resistance which the two kinds of ice presented to the atmosphere was the cause of the furrows and ridges. After having followed them for several hundreds of yards, I reached a fissure 20 or 30 feet wide, which as it cut the plates and furrows at right angles exposed the interior of the glacier to a depth of 30 or 40 feet, and gave a beautiful transverse section of the structure. As far as my vision could reach I saw the mass of the glacier composed of layers of snowy ice, each two of which were separated by one of the plates of which I have spoken, the whole forming a regularly laminated mass, which resembled certain calcareous slates." The blue vein structure has been attributed to the stratification caused by the annual falls of snow; but there are several objections to this view, amongst which may be mentioned the fact that the structure is vertical, not horizontal, and that the bands are not continuous, but occur as a multitude of short streaks disconnected from, but parallel with, one another. Forbes appears to have accounted for it in his latest publications by the action of pressure on the ice, producing lamination. Tyndall advocates a very similar view. Thus he mentions many familiar cases of lamination being produced by a weight rolling or gliding over a soft, pasty, plastic mass, as in making puff paste. A similar action occurs in a glacier. The central portion moves faster than the sides, the disproportion being greatest where the pressure is most energetic. The sides are retarded by the environing rocks. Hence the median ice is pushed past the plastic lateral ice, much in the same way as the roller passes over dough, squeezes out the ice, and then induces lamination, which usually forms a right angle with the marginal crevasses. Lamination, however, also occurs in other parts of the glacier, but in all cases it is best displayed where a sliding pressure is most powerful. In order to show that the lamination is a different thing from stratification, Tyndall searched long for an example of what is found in terrestrial strata, viz., of cleavage cutting the line of bedding at an angle. He describes one example in the Aletsch glacier, and a second in the Furgge glacier. Pressure, then, may account for the laminated structure; but it does not by itself explain the appearance of the blue bands. To understand how they are formed, we must recur to some of the properties of matter in general, and ice in particular. A liquid possesses a certain cohesive force, and when heated it begins to boil as soon as this is overcome. This force corresponds to a definite degree of heat. If a weight is placed on the fluid, the heat has to overcome the resistance of both the cohesion and the superincumbent pressure, and hence more heat will be required. In other words, the temperature of the boiling point is raised. In like manner, the fusing point of a solid may be raised by pressure. This statement is true for all substances which expand when passing from the solid to the fluid condition, and contract when they solidify. Bismuth, however, contracts on fusion, and in its case external pressure would aid to bring the particles together, and assist the action of heat. Bismuth will fuse at a lower temperature when subjected to pressure. Ice behaves like bismuth in contracting when it solidifies, and hence its fusion may be expected to be facilitated by pressure. Messrs. Thomson have experimentally proved that external pressure enables the ice to liquefy at a lower temperature than 32°. If this be true, then, pressure alone should cause ice at 32° to partially liquefy. Tyndall placed a small cylinder of clear ice in a press, and on watching the ice he saw cloudy lines make their appearance, which augmented as the pressure was continued. When looked at obliquely the ice had a laminated appearance. In order to show that the cloudy condition was not due to air which had penetrated between the laminæ, the experiment was repeated with the cylinder in water, and again, when partially in the water and partially in air, but the result in all cases was the same as at first. To show that compression, and not tension, produced the lamination, a cylinder with one of the ends oblique to the axis was placed in the press. The flat end was flush with one side of the press, but the oblique face could only touch the opposite side by its extreme point. The upper side of the cylinder would, therefore, be longer than the lower. On putting the press in action, the longer and upper side was squeezed in air till it was shortened to the length of the lower side. The upper side, where compression had taken place, showed the lamination, whereas the lower side, which had not been pressed, retained its original clearness and homogeneity. The surfaces of the laminæ were hazy, and Tyndall states that "had the spaces been filled with air, or were they simply vacuous, the reflection of light from them would have been so copious as to render them much more brilliant than they were observed to be. To examine them more particularly, I placed a concave mirror so as to throw the diffused daylight from a window full upon the cylinder. On applying the pressure, dim spots were sometimes seen forming in the very middle of the ice, and these as they expanded laterally appeared to be in a state of intense motion, which followed closely the edge of each surface as it advanced through the solid ice. Once or twice I observed the hazy surface pioneered through the mass by dim offshoots, apparently liquid, and constituting a kind of decrystallization. From the closest examination to which I was able to subject them, the surfaces appeared to me to be due to internal liquefaction; indeed, when the melting point of ice, having already a temperature of 32°, is lowered by pressure, its excess of heat must instantly be applied to produce this effect. . . . The ice of the glacier must undoubtedly be liquefied to some extent by the tremendous pressure to which it is here subjected. Surfaces of discontinuity will in all probability be formed, which facilitate the escape of the imprisoned air. The small quantity of water produced will be partly imbibed by the adjacent porous ice and will be frozen when relieved from pressure. This action, associated with that ascribed to pressure in the last section, appears to me to furnish a complete physical explanation of the laminated structure of glacier ice."

The subject of the waste of glaciers is scarcely touched upon in the original article, the only reference to it being the notice of the trickling streams and gushing torrents which result from the dissolution of ice. It is an important one, more especially in its relation to the hypothesis respecting the larger dimensions of glaciers in former ages. The length of a glacier depends not only upon the quantity of ice which is forced down the valley, but upon the speed with which it travels, and the rate at which waste proceeds. For instance, it will be short in proportion to its shallowness relatively to its mass, since the waste proceeds most rapidly at the surface. There are, however, various compensating causes. If the glacier is shallow, the probability is that the valley is wide, and as the friction will be less than in a deep gorge the ice as a mass will flow down faster, supposing the inclination to be the same in the valley as in the gorge. It will be short in proportion as the angle of slope is less, for since it will flow more slowly it will be longer exposed to destructive agents. It will be short in proportion as the summer's heat approaches in equivalency the winter's cold; so that the size of the glacier is influenced by the average annual temperature, and not exclusively by the nature of the winters or of the summers. Assuming that a glacier has an average rate of 550 feet per annum, which is the average velocity of the Mer de Glace in summer, opposite the Montanvert Hotel; that the average width is one mile; and the average depth 400 feet. In such a case, the quantity of ice passing by a given point daily in summer would be a little over three million cubic feet, and in winter it would be about half this amount. So that the flow may be estimated at about two million cubic feet per day annually. Assuming, also, that twenty feet of the glacier is melted away annually, it would follow that it would come to a termination about two miles lower down. The amount of waste above assumed is not excessive, for many stones are raised or rather sustained on pedestals of ice 13 or 14 feet high, and generally slip off once or twice a year. The surface water, moreover, melts out channels for itself in the body of the glacier, and the bottom is believed to be more or less liquefied. Or we may refer to actual measurements. Forbes found that at a station on the Mer de Glace near Montanvert the ice moved nearly 19 inches daily in July and August; that 3·62 inches were removed from the surface by solution, which is equivalent to about 18 feet in two months only. If it happened that the same quantity of ice was poured down the valley, and that only 10 feet of the surface was dissolved away annually, owing to a succession of cold or cloudy summers, this would enable the glacier to extend much farther. If the conditions were otherwise precisely the same, it would stretch two miles farther; but the extra stretch would be considerably shortened by the greater heat of the lower district, and by the tendency of the extra ice to fill up the valleys to a greater height. In almost all cases the variation in the size depends partly upon the winter and partly upon the summer temperature and serenity of the sky. An example of the increase of a glacier in recent times may be given. In the Alps the year 1818 was marked by a great extension of the glaciers, and 1846 presented a similar but smaller increase. The last augmentation was due to the heavy snowfalls in 1843 and 1844, followed by cold wet summers. The snow protected the glacier, and enabled it to traverse a greater distance while undergoing the same amount of waste. The glacier of Brenva was visited by Forbes in 1842 and 1846. In the former year a larch tree just at the end of the glacier was 300 feet above it; while in August, 1846, it was not more than 100 feet above the surface of the glacier. The glacier was advancing rapidly, partly in consequence of the great accumulation of ice, and partly in consequence of the great heat of the summer of 1846. In two months it had advanced 70 feet. Forbes remarks that were the climate of 1844 and 1845 permanent there would be an enormous advance of the glaciers; and that a more turbid and cloudy atmosphere, with an increase of the usual precipitations, would suffice to increase glaciers to almost any extent, even that which is required to account for the erratic phenomena, a temperate climate being most favourable to the growth, especially the progression, of glaciers.

Before alluding to some of the facts demonstrative of the vast extension of the glaciers in the glacial epoch, allusion may be made to one or two of the theories connected with the recent glaciers. Rendu, Bishop of Annecy, was a man of powerful intellect, and was the author of a highly original work on the theory of glaciers, published in 1840, which work seems to have been entirely overlooked for many years. He seems to have been amongst the first to recognize the veined structure, and was fully aware of the plasticity and regelation of ice. His views as to the principal way in which the ice is compelled to leave the mountains are quite original. He points out that ice can only support a given pressure without being broken or squeezed out. When, then, the snow or ice exceeds a certain thickness, the lower portion is compelled to give way. He says that something of this kind really occurs on Mont Blanc, and experiment has fully confirmed his views. The idea is especially applicable in explanation of comparatively level countries, such as Greenland, for it is very doubtful if gravity alone will impel an ice cap down a gentle slope, in consequence of the enormous retarding effect of friction. A glacier which is not connected with a large snowfield, and which is of comparatively slight thickness, rarely possesses much motion, however steep the incline may be. This is illustrated by a small glacier on the northern face of the Schönhorn, just behind the Simplon hospice. It is about 8000 feet above the level of the sea, and the slope is in places 20°, 25° and 35°. It is about 1000 feet long, and 1300 in its greatest width. Its rate of motion in July was between one and two miles daily.

M. Rendu insists upon the power of the ice to mould itself to the configuration of the ground like a paste, and, after pointing out the great discrepancies in the guides' estimates of the rate of motion of a glacier, remarks that it arose from the great difference in the speed of the central and lateral portions, the latter being retarded by friction against the sides. He, moreover, seemed to be fully aware of many other sources of discrepancy, for he says no general measure is obtainable, each glacier having its own rate, which rate is influenced by the slope, the depth of the ice, the width of the channel, the shape of its sides, and a thousand other circumstances. The velocity is great where the inclination is steep and the ice thin; and where a steep slope is succeeded by a less inclined one, the glacier swells and accumulates. And he is so impressed with the fluent nature of glaciers that he affirms that the resemblance is so complete between the Mer de Glace and a river that the one presents all the peculiarities of the other. His knowledge was equal to that of many of the most distinguished subsequent observers, but he had not discovered those physical qualities of ice by virtue of which it moved like a river, and became streaked with bands of blue ice by pressure.

Professor J. Thomson's hypothesis as to the motive agent of glaciers is in the main a modification of the hydrostatic principle advocated in various forms by so many glacialists. It differs from previous hypotheses in the way in which it accounts for the presence of the water, and in the position assigned to it. His view was that by pressure portions of the glacier were liquefied, the water being squeezed through any crevice it can get into, and on the diminution or withdrawal of the pressure, the water is again frozen. This action he believes is constantly going on, so that every portion of the ice is liquefied in turn. The myriads of minute motions thus produced have their resultant in the general downward movement of the glacier.

We have made frequent allusion to a glacial epoch, an epoch when glaciers were rife and abundant throughout the polar portions of both hemispheres to an extent far beyond the conception of many persons. Not only did large glaciers exist where now every particle of snow disappears every summer, but such localities were the scene of the most extreme degree of glaciation, such as is now typified by Greenland, Spitzbergen, and other ice-clad areas. A general account is given of this epoch under Post-Pliocene, E. C. S., but something may be said here of the old glaciers. We assume that the reader is familiar with the peculiar marks of a glacier, such as moraines, striated surfaces, elevated boulders, &c. One thousand feet above the level of the Aar glacier are to be seen rounded and striated contours, which demonstrate that a glacier, and no doubt the Aar glacier itself, flowed along at this elevation. It may be supposed that a glacier, similar in size to the present one, may have flowed when the valley bottom was a thousand feet higher than now, and that the difference of level has resulted from glacial erosion. That there has been erosion there can be no doubt, and as little that erosion has been going on for a very long period of time. That the glacier was really thicker, nay much thicker, is rendered very probable from the evidence that exists, showing that the length of the glacier was at one time immensely greater than now. Further, when the hills which separate many of the present glaciers from one another are examined, they are found to bear all the marks of having been overflowed by glaciers, showing that the old ice capped elevations now free from it. And, if to add still more convincing testimony, large terminal moraines exist to mark the extreme extension, which was very much lower down than any of modern date. Thus at Ivrea, there is an immense moraine, which was deposited by a glacier whose length is estimated at 104 miles, and which filled the valley of the Aosta to a height of 2000 feet. There was a still larger glacier in the valley of the Rhone, which commenced in the Seidelhorn, extended down to the Lake of Geneva, where it spread out in a fan-shaped mass which abutted against the Jura Mountains. Some authorities believe that the glacier did not extend so far, but that the blocks on the Jura were floated from its terminus across a wide arm of the sea which flanked the Jura Mountains. Guyot has carefully examined the question, and has shown from the disposition of the boulders or morainic matter throughout the plains of Geneva and Berne, that the probability is in favour of their having been transported by glaciers, not by icebergs.

The region round Snowdon presents many signs of glacial action, the walls being round, mammillated, and striated, from the level of Llyn Padarn to a height of several hundred feet above it. Moraines exist in many places, a fine one occurring at the entrance to Cwm-glas. Traces of glacier action are conspicuous in six of the principal valleys which debouch from Y Wyddfa, but they are especially remarkable in the pass of Llanberis and the valley of the Rothel, as also in Nant Francon. The Llanberis glacier appears to have been about three miles long and several hundred feet, probably as much as 800 feet deep. The kind of scene which the Pass of Llanberis presents has been sketched by Professor A. C. Ramsay in the following terms:—

“Up the Pass, every step beyond Llyn Peris, the signs of a vanished glacier become more and more apparent. Erratic blocks, mingled with smaller moraine matter, lie on the roadside and up among the rocks, easily distinguished by the experienced observer from more modern blocks and talus that lie below the weathered cliffs. On both sides of the valley the rocks, strewn with blocks, frequently present the well-known *moutonnée* form, more or less perfect; and this is especially plain towards the turnpike gate, and near Pont-y-Gromlech, where bosses of felspathic porphyry rise like little hills in the middle of the valley, something like miniatures of that behind Grimsel. Though their sides have been scarred by the winters' frosts, their summits, roughened by the weather, still retain the largely mammillated form impressed on them of old by the grinding ice; and while the tourist who sees something in scenery beyond mere external form is often puzzled to account for the numerous blocks that, perched on precarious points, seem as if they ought to have taken a final bound into the lower valley, the well-pleased eye of the geologist, versed in ice, at once detects that they were let gently down where they lie by the melting of the diminishing glacier. Further up the valley, behind Blaen-y-nant, a brook descends from the hollow of Cwm-glas. A little way up its banks, a good-sized moraine, afterwards to be more particularly noticed, has been cut through by the stream, and bends up both its banks. Above this, going up the Pass, the ground on the right is all covered with moraine débris, and nearly opposite the great fallen blocks of stone, now called a cromlech, a huge mound, worthy the name of a hill, rises in the valley between the road and the upper side of the entrance to Cwm-glas. So large are some of the angular blocks with which it is studded, that for some time I was doubtful if the hill did not chiefly consist of a solid mass of felspathic porphyry, but the mixed nature of its fragments, its form, and position, after many a visit, forced me to the conclusion that it is the relics of a large moraine, shed from the upper side of a glacier that once descended from Cwm-glas, and abutted on the opposite side of the Pass. Below Pont-y-Gromlech, there are other traces of moraines, and several erratic blocks—one of them of greenstone—lie perched on a large rounded boss of felspar porphyry. The ice furrows on its surface are almost all weathered away, but such as are traceable trend towards Llyn Peris, and, as is frequently the case, the more broken side of the *roche moutonnée* faces down the valley. Opposite, above the bridge, on the Snowdon side of the valley, a great dark wall of rock rises abruptly from the broken lower slopes, about a quarter of a mile from the road. From the bottom of the Pass it looks almost inaccessible, but half-way up there is a rough terrace at the foot of a greenstone dyke that forms in part the face of the cliff. The slope of the precipice is about 68° towards the Pass, and in one place especially the wall of rock is polished, and striated in at least six principal grooves which slope down the valley (not down the hill) at an angle of 12°. Some of these are deeply graven, from two to two and a half feet wide, and twelve or eighteen inches deep, and they run so evenly along an almost vertical wall of rock, that the idea is at once suggested that they were formed by the long-continued pressure of a glacier, so large that it filled the valley to a far greater elevation than the groove, and by reason of the huge overlying mass of ice a middle stratum, as it were, of the glacier was jammed against its bounding walls so powerfully that by help of the grinding of imprisoned stones, in time, it graved the strong furrows still so perfect. To the very top of the Pass the same kind of evidence, both of moraine débris and striation, continues unabated, especially on the higher slopes on the north-eastern side of the valley, where, above the modern shingle and broken cliffs that overlook the brook, numerous *roches moutonnées* remain still partly unweathered, and here and there dotted with *blocs perchés*. By the road at the twelfth milestone a good instance occurs of a *roche moutonnée*, easily seen by those who are satisfied with roadside geology. Its curving outlines are perfect on the top, but at the sides it has been shattered by the weather. Close by the waterfall at Gorphwysfa, the striæ on the rocks still run north-westerly in the direction of the Pass, like those that must now be forming at the snowshed of the Upper Aar, and other glaciers. Once fairly across the watershed, where the valley widens, they rapidly curve round with the average slope of the ground, some passing in the direction of Nant-y-gwryd towards Capel Curig, and others down Nant-gwynnant.”

But Europe is not the only place where ice seemed to have reigned most triumphantly, for similar evidence to that already adduced has been afforded by America, Asia, and even New Zealand. In the last-mentioned country the glaciers which now descend but a little way down the mountains, reached as far as the present level of the sea during the post-pliocene period. The whole of Canterbury province seems to have been one ice-field, which may have exceeded the present land area. So far as explored, the larger portion of the western slopes of the Southern Alps are covered with morainic accumulations. Haast has mapped out the extent of the post-pliocene glaciers. Many of the principal promontories, such as Abut Head, Bold Head, Cliff Head, are formed of terminal moraines, and the lengths of the principal ice-streams varied from 25 to 50 miles, and one which existed, it is said, before the post-pliocene period, was 78 miles in length.

In the Himalayas the glaciers are now on a grander scale than anywhere else, some of them being fourteen or fifteen miles long, while several others are longer still, the Chogo glacier being twenty-four miles, and the Biafo glacier more than forty miles from end to end. During several years past they have been on the increase, some having extended their length by one or two miles within the memory of the present generation. But enormous as these are, they are not to be compared with the gigantic ice-streams of former, probably post-pliocene, times, some of which were 100 miles or more in length.

The time is not ripe for a complete theory as to the cause or conditions which brought about the great size of the glaciers in the post-pliocene period; mainly because there are so many things to take into account; and probably most of the hypotheses hitherto started have some truth in them, but, as seems to us, they fail because they do not state the whole truth, and nothing but truth. The correct theory will combine the truth of all, and add that wherein all are deficient. Professor Frankland's idea is very ingenious. He insists that the true explanation is not that there was a greater degree of cold, for that, he remarks, would diminish the quantity of snow, but a higher temperature of the ocean. He devotes a long discussion in support of his view, and endeavours to show that the ocean formerly had a higher mean temperature in conformity with the gradual cooling of the globe; and that it was when the snow line reached below the tops of the mountains that the most copious deposits occurred. As the temperature declined, the evaporation would be less rapid. But the main fact to prove is that the ocean (as a whole) was really so much warmer as to account for the great snow fall; and further, it has to be proved that the greatest extension of glaciers was simultaneous throughout the earth. Tyndall has pointed out that the most favourable condition for the condensation of vapours is a great differentiation of temperature. But Frankland's view appears to be inconsistent with the nature of the fauna and flora, which bear strong evidence that both the land and the ocean contiguous to the ice-clad lands was much colder than now. It would be quite in harmony with the facts to suppose that the snow-bearing air currents flowed over more southern and warmer seas prior to depositing their load on the mountains in the post-pliocene period than now. This is the suggestion Escher von der Linth has made. He said, in 1852, that the colossal dimensions of the old Alpine glaciers would be accounted for if the Sahara was once a sea. It has since been proved that the Sahara was once covered by salt water to a depth of 900 feet or more, and that too within a comparatively recent period. Its maximum width was, according to Tristram, 800 miles. The nature of the fauna of the desert and of the surrounding lands harmonises with this fact. [Geographical Distribution of Animals, E. C. S.] If an air current passed over this sea it would materially aid in increasing the snow-fall, and the point to establish is that a current did pass over the Sahara sea and impinge upon the Alps. This has not, we believe, been proved yet, but the probability of the case is very strong, seeing that a wind frequently blows now from the Sahara to the Alps. But the conditions are changed, and if the post-pliocene wind under the circumstances stated was a snow-bearing current, it ought now that it passes over a dry and thirsty desert to have the power of depositing very little snow, since it can get but little moisture from the Mediterranean. The wind we speak of is well known as the Föhn, and Escher and Denzler have observed that when prevalent it has melted away one foot of snow in four hours; and Irscher has seen the snow line rise on the mountains when this wind blows. It has been observed that if, during a series of years, the Föhn blows for a less number of days per year, the glaciers increase. If the Föhn absolutely ceased how much greater would be the effect. But if the Föhn were saturated with moisture it would become the principal feeder of the glaciers and not their devourer. If the land was much higher, as there is good evidence to show; if the reservoir for the snow was less inclined, which also there are good grounds for believing; if the Gulf Stream were deflected; if the lower atmosphere of the Alps were moister, as would be the case with a saturated wind from the Sahara; if all, or the most of, these points be established, we should have the groundwork for a sound hypothesis. There is little question that if these conditions existed they would account for the great extension of glaciers as satisfactorily as Professor Frankland's hypothesis; but what is wanted is an exhaustive analysis of the evidence pointing out the probabilities of each and the extent to which each contributed to the common result.

(Tyndall, *Glaciers of the Alps*; Ramsay, *Old Glaciers of Switzerland and North Wales*; Godwin-Austen, *Journ. Roy. Geog. Soc.* xxxiv. p. 19; Haast, in same vol., p. 87; Forbes, *Occasional papers on the theory of Glaciers*; Frankland, *Reader*, III. p. 171; Lyell, Sir C., *Report of the Thirty-fourth Meeting of the British Association for the Advancement of Science*, p. lxx.; etc.)

GLAUCONITE [Foraminifera, E. C. S.].

GLYPTODON. The early bibliographical history of this genus having been given under Megatheriidæ [E. C. vol. iii. col. 759], we resume the thread with the year 1846, when a great number of fossils were collected by Dr. Numez on the banks of the river Lujan, near Monte Video. They were given by Vice-Admiral Dupetit, who took them to Paris, presented some to the Museum of the Jardin des Plantes, and reserved others for himself. On his death, those in his own collection were transferred to Dijon. From these collections M. Nodot obtained the large proportion of the skeleton of an animal which he looked upon as closely allied to the *Glyptodon*, but distinct from it, and to which he gave the name *Schistopleuron*. He recognised three species; and has given descriptions of the bones belonging to them in his under-mentioned memoir, published in 1857. A fine specimen of *Glyptodon* was discovered in 1860 on the banks of the Salado in Buenos Ayres province, which was shortly described by Huxley in 1862, and more fully in 1865. In 1863 M. Serres pointed out some anatomical peculiarities in the skeleton of *Glyptodon*, which enabled the animal to withdraw its head beneath its carapace for protection from danger. In 1865 Herman von Meyer gave an elaborate description of the skull of *G. clavipes*, and in this year Serres contributed some facts relating to the anatomy of this species, as also of *G. ornatus*. In 1866 Serres described a new species, *G. giganteus*; and Burmeister enunciated his views on the classification of *Glyptodon* and its allies, and gave an account of the specimens existing in the Museum at Buenos Ayres.

Burmeister considers that the *Schistopleuron* of Nodot is not admissible since one species is a *Glyptodon*, and the others belong to the genus previously established by Lund under the title *Hoplophorus*. His definition of *Glyptodon* is—"tail elongated, conical; the rings before the apex formed of flat shields or scales; the apex more or less cylindrical, with a bulbous swelling at its commencement; mesocervical bone, with five united vertebræ." *Hoplophorus* is defined as having the "tail short, conical, with six rings of large conical tubercles on the end of each ring of the upper side of the tail; mesocervical bone consisting of four united vertebræ, the sixth free; scales of the carapace with one hexagonal figure in the centre, and six pentagonal ones on the circumference."

In Nodot's paper full descriptions are given of the bones, the probable habits, and the classification of the forms which Burmeister assigns to the two above-mentioned genera. Nodot believes the tail was used partly as a fulcrum to sustain the heavy armoured beasts when they reared themselves upon their plantigrade hind feet against a tree for the purpose of plucking its leaves or branches; and partly as a defensive weapon, a switch from the tail being sufficient to repel most enemies. He thinks that the power of pronation and supination possessed by the short and powerful forearm implies that these animals were active diggers. As their enormously thick buckler (which covered every part of the body, and beneath which the head could probably be drawn) afforded them considerable protection from external foes, he is inclined to accept the view that these edentates excavated the ground for food, and not to construct a burrow wherein to retreat. But *Glyptodon* probably was not without enemies. Nodot believes the strong fanged *Machairodus smilodon* partly sustained itself upon *Glyptodon* and *Hoplophorus*. The feline was powerless when it attacked the edentate from behind, since it would crouch on the ground with its head tucked under the carapace, and hammer with its mighty tail. If, however, the feline attacked it in front, it would, as is conjectured, rear itself upon its hind legs, and in so doing, would expose its soft plastron through which the *Machairodus* could readily deal a deathblow with its fangs. The jaguar is accustomed to capture tortoises in this way.

We have not thought it desirable to enter into anatomical details here, for which we would ask the reader to consult the undermentioned works.

(Nodot, *Déscription d'un nouveau genre et Edente Fossile renferment plusieurs espéces voisines du Glyptodon. Mém. de l'Acad. Imp. des Sciences du Dijon*, Second Series, vol. v.; Huxley, *Philosophical Transactions*, vol. clv., p. 31; Serres, *Comptes Rendus*, vol. lvi. pp. 885, 1028; lxi. pp. 457, 537, 635; lxii. p. 207; Mayer, *Palæontographica*, vol. xiv. p. 1; Burmeister, *Annals and Magazine of Natural History*, Third Series, vol. xviii. p. 299.)

GOLD. Numerous details respecting this metal may be found by reference to the articles Gold in the Nat. Hist. and Arts and Sci. Divisions of the Cyclopædia, as well as to numerous articles in the Geog. Div., under such titles as Australia, Africa, Asia, California, &c. On comparing the accounts of the first discovery of gold in Australia, as given under Gold, Nat. Hist. Div. col. 1067, and under Australia, Geog. Div., several discrepancies will be noticed. The latter is, we believe, strictly accurate, and may be considered as supplementary to what is stated in the present Division. It may, however, be mentioned that even before Strzelecki discovered the metal, the existence of the gold was well known to many of the shepherds. The term native gold does not imply that the metal is pure; indeed, no absolutely pure specimen has yet been met with. Silver forms varying proportions of all the specimens that have been carefully examined; while traces of copper and iron are also generally present. The frequent association of these metals is the more interesting, when it is remembered that iron or copper pyrites are almost always permeated with small quantities of gold.

As silver is much lighter than gold, it would naturally be expected that native gold would be lighter than pure gold; but this does not suffice to explain the variations actually met with. The specific gravity of pure compact gold is 19·2 or 19·3, and that of pure compact silver is 10·5; but native gold is always lighter than its composition would indicate, so that the specific gravity does not wholly depend upon the alloying metals present. For example, a specimen from the Rivière du Loup in Canada had a specific gravity of 16·65, and contained 13·60 per cent. of silver. On hammering and annealing it the specific gravity was increased to 17·02, indicating a considerable degree of porosity. Hence two specimens having almost identical compositions may vary in their specific gravity in consequence of their different degrees of compactness. An example of this is presented by the specimens analysed by Rose: (1) from Alexander Andrewjewsk, and (2) from Petropawlowsk :—

	(1.)	(2.)
Gold	87·40	86·81
Silver	12·07	13·19
Copper	·09	tr.
Iron	tr.	tr.
Sp. gr.	17·40	16·86

The specimen from Marmato, with a specific gravity of 12·66 (mentioned in E. C.), probably owed its lightness to a more than usually high degree of porosity. If a specimen having the composition assigned to this were made of ordinary compact metals, its specific gravity would be 16·93.

Gold is so commonly regarded as a substance which retains its metallic solid nature amidst all the conditions to which it is naturally exposed, that it seems desirable to point out here that nitromuriatic acid and mercury are only two out of many substances which will dissolve gold; and that, as will be shown further on, there are numerous facts which indicate that native gold has been, and is now being, distributed by means of solutions as well as by mechanical forces. Gold is soluble in nearly all the ethereal solutions of the perchlorides and perbromides; in many of the sesquichlorides and sesquibromides; in the ethereal protiodides; and in all liquids from which chlorine, bromine, or iodine can be liberated in the nascent form. In this general statement we have indicated hundreds of solvents for gold, but a few of them may be referred to more minutely. The solvent power of nitromuriatic acid is not due to the acid itself, but to the nascent chlorine which is liberated by it. A solution of perchloride of manganese forms a good solvent; it has a green colour, which gradually becomes lighter as the gold disappears, owing to the reduction of the perchloride to the insoluble protochloride. On heating the residue obtained by evaporating the liquid, the gold will remain as a layer adhering firmly to the sides of the vessel, but it may readily be detached by means of hot nitric acid. This is the basis of the new method of extracting gold from auriferous ores, proposed a few years ago by Mr. Crace-Calvert as a substitute for amalgamation, an account of which is published in the 'Report of the British Association for 1864' (Notices), p. 25. Another method, that of Plattner, is based upon the solvent power of water when saturated with chlorine. If gold leaf be placed in ether, and a stream of iodhydric acid gas be passed through the fluid, the metal will rapidly dissolve. Iodine alone has no effect on gold, nor has the ethereal solution of this element; but it forms an excellent solvent when gold is exposed along with moist iodine to a strong sunshine, or to a temperature of 50° C. In this way iodide of gold is formed, which, when slightly heated, deposits a film of gold. Another excellent solvent not comprised in the above-mentioned group, is cyanide of potassium, and is the one largely used by Professor Faraday in his remarkable researches on the relations of gold to light.

These researches showed that the yellow colour of gold belongs to it under certain circumstances only, and that by altering the physical conditions the colour will vary considerably. In the compact massive state it is perfectly opaque, and has a yellow colour by reflected light; when beaten out into gold leaf with a thickness of about $\frac{1}{280000}$th of an inch it still appears yellow by reflected, but is translucent, and of a greenish colour by transmitted light. Such a leaf is full of holes, and it might be supposed the alteration is due to this circumstance; but an examination with the highest known microscopic powers shows that the translucency and green colour belong to the continuous parts only. If such a leaf be placed in cyanide of potassium until its thickness is reduced to $\frac{1}{30}$th of its former dimensions, it still retains its power of transmitting a green colour; but when this film is placed in a hot-oil bath for five or six hours, cooled, and freed from oil by washing with camphine and alcohol, the thinner parts are colourless by transmitted light, while the thicker parts are pale light green. If this be pressed with a burnisher, the green colour is restored. This is doubtless due to the film being puckered up into folds, and thereby thickened. By placing phosphorus on a solution of gold, films may be obtained of almost any degree of tenuity desired. The film formed is at first colourless; as it gradually thickens it acquires a feeble grey violet tint, then violet, greenish violet, and ultimately becomes more and more green. When a grey violet film is placed on a solution of cyanide of potassium it acquires a green colour in the act of dissolving; if laid in a solution of chlorine it acquires a ruby tint; and if heated it becomes purple. As will be seen, a change of thickness produces a change of colour, but the latter change is also brought about by other physical alterations. Thus, for example, if minute particles of phosphorus be placed in a solution of gold, a ruby-coloured fluid will be formed, which owes its colour to the suspension of exceedingly minute particles of gold. The quantity of metallic gold present may be so regulated that a given depth, say two inches, will contain as much as corresponds to an ordinary gold leaf. In both cases there may be the same quantity of metal between the eye and the light, yet the leaf is green, and the fluid ruby tinted. The latter retains its colour, even when diluted with twelve times its volume of water. Again, if a few drops of the ruby fluid be touched with common salt it turns blue, and sometimes colourless, and yet, according to Professor Faraday, the gold is chemically unaltered, and remains still in suspension. Many other substances besides salt will produce the same effect. The reducing action of phosphorus on gold solutions has been incidentally mentioned; and another reducing agent, or rather a group of them, may be referred to, viz., animal substances. Every person who has had occasion to work with gold solutions is familiar with the grey violet stains produced when the skin touches them. These stains are due to metallic gold in a similar state to the similarly coloured films formed by the action of phosphorus on the same solutions. Gold is also easily precipitated from its solutions by many vegetable acids, most metals, and many ferrous salts.

In considering the distribution and mode of occurrence of gold, there are a few considerations which ought not to be wholly overlooked. First, the larger portion of our information is derived from persons whose knowledge is mainly gathered from one district, from which circumstance they are more or less liable to consider that the order of importance of the phenomena in their district is the same as will be found in all other districts; secondly, the usual object with those seeking a knowledge of the natural occurrence of gold has a practical rather than a scientific end; and, thirdly, it is exceedingly difficult to discuss the question as to the agencies by which gold has been deposited in veins without being more or less unduly biassed towards the aqueous, igneous, or hydrothermal origin of those veins. In short, it may be said that many of the hypotheses respecting gold have proved to be erroneous, and that the error has been discovered by the accumulation of further evidence gathered over a wider field. For example, twenty years ago it was the received opinion that gold was abundant only in the uppermost 100 or 200 feet of the earth's strata—an opinion which receives no support now. One eminent geologist has expressed his belief that all the veins of the Silurian rocks received their charge of gold during the tertiary period. Another has asserted that the metal is found in pliocene gravels, but not in miocene, and from this has argued that the metal appeared in the original rocks during the interval which elapsed between the deposition of the two sets of gravels. Other geologists and mineralogists have repeatedly asked why it is that gold is only found in the most modern gravels and clays, seeing that the original seat of the metal is in the old Silurian rocks, and that these rocks have been subject to denudation from the later part of the Silurian epoch through all Mesozoic and Cainozoic times. Why are there no Mesozoic auriferous drifts? These and other opinions will receive more or less consideration in the sequel, when we inquire whether the premises on which they are founded are true, viz., that gold is only found in superficial deposits or in post-pliocene gravels; and that auriferous quartz veins were not formed prior to the secondary or even the tertiary period. But before entering upon the known facts respecting the occurrence of gold, we would admit that much evidence is yet required before a satisfactory determination can be arrived at as to the period when and the process by which the various auriferous veins were formed.

The geographical and geological distribution of gold may be regarded from two very distinct points of view, viz., that of the miner or gold-seeker, and that of the naturalist. A great deal of evidence has been collected from the former, but little from the latter standpoint. Thus, gold-seekers are unusually stimulated when they hear of masses being found weighing 2166 ounces, and containing upwards of 2000 ounces of pure metal, as in the case of the 'Welcome' nugget, or even 210 lbs., as in that of the nugget found in the Donolly district, in March, 1869. They consider themselves fortunate when they come upon a quartz vein with 330 ozs. of gold to the ton of gangue, as at the Clogau mine, near Dolgelly, in Wales; and still more so when the same quantity of gold occurs in a ton of gravel or sand, or where the metal forms about $\frac{1}{1000}$th part by weight of the whole mass of material. They will even work quartz with 4 dwts. to the ton, where one part out of about 160,000 only is metal; while the gypsies of Europe will wash sands which contain even less than this. There are, however, many deposits where the proportion of gold is so minute that it would be folly to attempt to collect it as a paying speculation, yet there may be as much gold in these as in the auriferous drifts. At present we have few facts bearing upon this branch of the subject, but researches made at the Sydney mint have shown that almost every distinct kind of rock found in Victoria, belonging to numerous geological ages, contain appreciable quantities of gold; and it is very probable that similar inquiries upon the rocks of other countries would lead to the same result. At any rate it ought not to be assumed that rocks of a given age contain no gold because it is invisible and does not contain it in a sufficiently concentrated form to be worth the miner's consideration. A proper examination of the rock is required before the absence of gold in it is admitted. The readiest method is with the spectroscope, which enables one to detect very minute traces of the metal far easier than by chemical analysis.

Gold occurs either in veins in certain rocks, or in the detritus formed from those rocks. As the first are generally considered to be the original locality of the metal we will begin with them. There are several kinds of veins. Lieber has classified them, and for want of a better arrangement we will adopt his grouping, which is as follows. (1) Silicious veins, which are subdivided into (*a*) quartzose veins, which, when followed downwards, resolve themselves into a matrix which contains little else than copper pyrites; (*b*) those in which the quartz is granular, and rarely contains copper ores; (*c*) the hornstone lenticular veins; (*d*) the hornblendic type. (2) Auriferous beds of the slates.

The true quartz veins (*a*) are perhaps the most common. The quartz has a highly crystalline hyaline appearance, and frequently a bluish tinge. Iron pyrites is most abundant in the upper part of the veins, while copper pyrites predominates below. These veins, in fact, are those from which copper ores are obtained, a more minute description of which occurs under COPPER, E. C. S. They are abundantly developed all along the eastern slopes of the Appalachian range; and generally contain a more or less auriferous gossan. When this is worked out the vein becomes more valuable for its copper than for its gold. The gold is rarely visible in the lowest parts of the vein where copper pyrites is found, but where copper pyrites and iron pyrites occur together, it appears more abundantly in minute particles, while higher up, or in the gossan itself, the particles of gold are generally larger. The veins have, in most instances, a north-easterly strike, and in the United States are most abundant in talcose and micaceous slates, although they have been found in gneiss, granite, and other rocks. It is noticeable that the veins are sometimes marked by peculiarities which seem to indicate that part of their contents were derived from the surrounding rocks. Thus it frequently happens that the flucan of the vein resembles talcose slate even when it is itself situated in micaceous slate or gneiss. In South Carolina, and in many other States, the gneiss and mica slate are frequently overlaid by talcose slate. Again, some of the veins in the micaceous slate have a sap-green mica interspersed through them, which is precisely like that in the surrounding slate. Lieber notices one vein in South Corolina, belonging to this group, which was associated with a mineral resembling tetradymite. In North Carolina this association has been several times found, as, for example, near Dahlonega; at Pascoe mine, Cherokee Co.; and near Van Work in Polk Co. On Sleepy Creek, in the Edgefield district of South Carolina, the silicious slates are more than usually cut up by planes of stratification, jointing, cleavage, and fracture; and sometimes the space between two principal veins is crowded with numerous irregular ramifications of auriferous quartz. In these districts it is very common for the veins to be connected with melaphyre dykes, or to be near masses of granitic and trachytic rock.

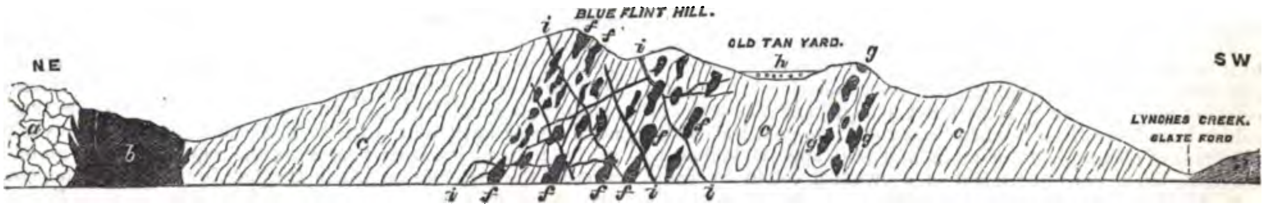

Fig. 2.

In the veins belonging to group *b* the quartz has an opaque, white, and granular appearance, like that of loaf sugar, whence it is called saccharoidal. Sometimes the colour is pure white, but frequently it has a peculiar yellowish tinge, due to the dissemination of peroxide of iron through it. The quartz veins of group *a* are generally persistent in their character, and continue to unknown depths; but those of group *b* are very irregular in size, and entirely change their character or else disappear as soon as they pass from the more or less decomposed upper rock to the part which is hard and undecomposed. This line is generally that below which water is met with. The gold in these is of very fine grain, and always more or less scaly; in many cases the metal is imperceptible, even where it may be abundant. These veins are exceedingly well developed all through the Atlantic States, from Vermont in the north to Georgia in the south. The difference in the nature of the quartz of these two groups of veins is especially remarkable. The opaque quartz veins are found in the most fissile and friable portions of the slate country, while those formed of transparent hyaline quartz are met with exclusively in the hardest rocks and near dykes.

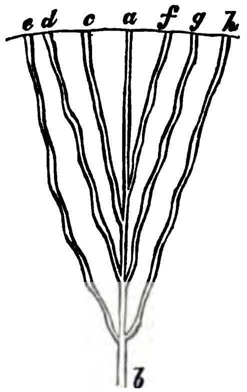

Fig. 1.

The hornstone lenticular veins forming group *c* are met with in the talcose slates of South Carolina, generally near a granitic and syenitic dyke. The veins consist of disconnected lenticular masses formed of a material so closely resembling the surrounding slates as to be with difficulty distinguished from them, more especially when they occur in the joints which are so arranged as to divide the slate into rhomboidal masses. The material of the vein, however, contains far more silica than the slates, and its lustre is adamantine rather than greasy; while its disposition in the rock renders its venous character evident. Thus it frequently happens that the veins are connected with one another as drawn in *fig.* 1, where *a b* is the principal vein, *e d c* leaders from it, with a high dip in one direction; and *f g h*, other leaders with a similar dip in the opposite direction. In some places it is remarkable that white quartz veins abound where the hornstone class occur, but contain no gold; and it is said that when they cross the hornstone veins they render them barren at the point of contact. At other places gold is found in both kinds of vein. The Brewer Mine in South Carolina is an instructive example of this class of veins, and a section of it is represented in *fig.* 2. The lenticular veins *f g* occur in talcose slate *c c*, and are intersected by numerous seams of white quartz *i i*. The lenticular veins have the same strike and dip as the slates, the former being N. 70°—72° E. and the latter about 63° to N. 18° W. The veins are formed of a string of kidney-shaped masses which are generally in a more or less decomposed state. They consist of a kernel of blue hornstone sometimes many tons in weight, which, when disintegrated, yields a fine impalpable sand like that formed of diatomaceous remains at Bilin. Iron pyrites, copper, a mineral-like tetradymite, and gold are disseminated throughout the mass, which is traversed by the same joints as pass through the slates. The fissures thus formed are usually more auriferous than other parts; some of them appear to have been filled up from above, for the gold is invariably more abundant in the vertical than in the horizontal seams, while it is not uncommon to find soft disintegrated masses rich in gold beneath portions of the vein which shows no signs of disintegration. The quartz veins in this mine do not contain gold. To the north-east of these veins there occurs a granitic dyke *a*, and a coarse trachytic rock *b*, while towards the south-west the talcose slate comes in contact with the mica slate. At first sight these masses do not have any resemblance to veins, but that they are such is rendered probable by the occurrence of slicken-sides on the walls of some of these veins. Dorn's mine in South Carolina is another interesting example belonging to this group. It has, however, some peculiarities which it shares with several other mines in its neighbourhood. Although placed in the hornstone lenticular group, it should be stated that no hornstone proper occurs in them, its place being taken by a peculiar form of silica. "At all of the mines the slate is more or less soft, or rather friable. It is largely composed of very finely divided quartz, which presents a good deal of the appearance of silica, chemically prepared through the medium of the gelatinous slate. It will be remembered that this peculiar feature of the occurrence of silica in such slates was already noticed in reference to Brewer mine. This very high per-centage of silica in these slates, often increasing to such an extent as almost entirely to exclude all other ingredients, is a very remarkable feature. Nor can it surprise us that under these circumstances it should often become absolutely impossible to separate the auriferous veinstone from the barren slate. Indeed, we may say that in every instance the veinstone changes with the slate. If the veinstone is a hornstone, as at the Huey mine, that hornstony character also prevails to a greater or less extent in the slate. If the gangue is composed of an open watery quartz, as often occurs at the Dorn mine, the slate also partakes of the same feature. If the gangue is a friable or even pulverulent granite silicious slate, we find that similar characteristics are possessed by the slate." (Lieber). Another peculiarity in Dorn's mine is the association of large quantities of psilomelane, or oxide of manganese with the usual hydrated peroxide of iron. On examining a fresh piece of slate black lines may be seen on it, along which it readily fractures. The surfaces obtained by fracture have a bright, glistening appearance, and, on examination with a lens, show that the black lines are minute cracks, the sides of which have been joined by columns or stalactites of the manganese ore; while, at some distance from the auriferous slates, is a bed of manganesian ore composed chiefly of psilomelane, but also containing pyrolusite, which has a width of from 50 to 100 feet, and whose black outcrop may be traced for miles. The gossan in the Dorn mine is more than usually deep, and the distribution of the gold in it has been carefully studied. The gold occurs in the largest particles wherever an open space exists, and it is richer where the vein begins to widen than in the narrow part immediately above. The gold in the undecomposed part of the veins is invariably less pure than that from the decomposed part. According to Lieber, "the upper gold is very yellow, and the lower very white, the inferiority in value being a result of additional silver. So regularly is this the case, that if we find two parts of the vein adjoining one another, the one oxidized, the other unchanged, we may even then discern the usual difference in the gold." This quotation is not very clearly expressed, but we gather from it that the gold in the decomposed parts of the vein is yellow, while that from the lower undecomposed part is white, owing to its being alloyed with silver, whereby its value by weight is diminished.

There are but few mines belonging to the *hornblendic type* (*d*) in South Carolina; and all these occur in *itacolumite*. The quartz has a greyish tint, and is exceedingly hard; hornblende is scattered through it in radiated acicular crystals associated with iron pyrites and mica.

The auriferous slate beds are almost entirely restricted to the talcose and clay slates, and are seldom met with. The Blackman and Hendrix mines in South Carolina are examples. In the former the slate is composed mostly of a talc with a colour ranging from silvery whiteness to a rich fawn and a bright green. "The presence of minute silicious accumulations about $\frac{1}{10}$ths of an inch in diameter has locally given it a wavy appearance. These diminutive quartzose nodules occur in the seams which were found to abound most in gold," although it may happen that parts presenting the same appearance will present no visible traces of gold. The metal predominates in the green bands more than in those of a greyish colour.

The above examples of gold deposits are taken from a limited district; but they have most of the features presented by such deposits in other parts of the world. Thus, other mines might be noticed yielding precisely the same class of facts from every part of the Appalachian chain. Throughout this region the gold appears to be confined to a particular band of rocks, having a length of 1300 miles, and a width of from 10 to 15 miles. They are generally considered to be of lower Silurian age. In the northerly portion the general strike is a little east of north; in the middle it is about 32° E. of north; while towards the south it is reflected still more towards the east. The rocks are chiefly talcose, mica, and clay slates, with occasional bands of steatite, serpentine, and itacolumite; they are frequently associated with granitic and syenitic rocks. The prevalent ores accompanying the gold are those of copper and iron, such as copper pyrites, covelline, erubescite, iron pyrites, magnetite, hæmatite, chromite. Rock crystal and psilomelane are also frequent. Thus in Maryland the gold is chiefly obtained from quartz veins in talcose slates. In Virginia it is obtained from a similar position. The Whitehall mine in Spotsylvania is worked in a deep blue clay slate; the principal veinstone is a hard white quartz, frequently marked with ferruginous stains. The gold is sparingly, though for the most uniformly disseminated through the veins, being exceptionally abundant in the iron-stained parts. Where the quartz is drusy the gold shows a tendency to crystallize. Native tellurium, as well as tetradymite, is here found with the gold. At Buckingham mines in Virginia the auriferous veins occur in talcose slates; the quartz is friable and granular, and much mixed with earthy brown iron ore; while copper pyrites, black copper ore, copper glance, phosphate of lead, occur in small quantities. When the quartz is most cellular, grains of gold are found in it, which show minute crystalline facets.

In Nova Scotia the same belt of rocks is found, accompanied by auriferous deposits. At the Tangier mines they occur in quartz veins traversing clay slate. The metal is disseminated through white quartz, associated with iron pyrites and mispickel, copper pyrites, magnetite, hæmatite, and galena, the first mentioned being especially abundant. As but little oxidation appears to have taken place, the quartz is compact, not cellular, and stained with hydrated peroxide of iron ore. At Lunenburg, also, gold occurs in quartz veins, bounded by clay slate, presenting the same features as at Tangier; but the mispickel is somewhat more abundant than at that place.

In Canada these rocks form the Notre Dame range, from which most of the gold-bearing alluvium of that country has been derived. At St. Francis rapids on the Chaudière, grains of gold are associated with galena, blende, and pyrites in a quartz vein, cutting slates supposed to be of lower Silurian age. In Leeds gold is found with copper glance and specular iron ore in a vein of bitter spar, and also in a white garnet rock at St. Francis.

On the opposite side of the American continent similar veins are thickly scattered along the western flanks of the Rocky Mountains, as well as throughout the Sierra Nevada range, forming part of the recently discovered gold fields of Cariboo, Vancouver's Island, and the Sierra Nevada. Thus, auriferous quartz veins cut through the talcose slates of St. Barbara County, California; while others traverse the slates, granite, and greenstone rocks of various parts of the Sierra Nevada gold-field. In Nevada County plates and angular masses of gold are imbedded in snow-white quartz, intimately associated with marcasite. At Gold Hill Mine, Grass Valley, large plates and crystalline fragments of the metal are implanted amongst the ends of quartz crystals. At Ophir Hill in the same valley the marcasite is highly auriferous. At Marble Springs, Tuolumne County, the opaque white quartz contains gold, associated with iron pyrites, galena, and zinc blende. At Mameluke Hill, Placer County, an auriferous quartz vein traverses talcose slates. The quartz is very cellular and friable, and is highly charged with irregular filaments, and ragged masses of gold. In Amador Co. auriferous pyrites abounds in quartz, traversing greenish-blue argillaceous schists, which are believed to belong to the oolitic period. Some of the mines are 900 feet deep, where the gold is as abundant as near the surface. One is 1200 feet deep, viz., that belonging to Mr. Hayward at Sutter Creek; the vein closely follows the edge of the granite, and descends almost perpendicularly the whole distance. It is wider and richer at the lowest part than in the upper parts. The veins have a north and south strike, and a high easterly dip. Near the surface the dip is as much as 70°, but it gradually diminishes in the lower part until it becomes nearly horizontal. At Austin auriferous schists, apparently of the same kind and age as those just noticed, surround a granite which is cut by innumerable quartz veins having a thickness of from 8 inches to 8 feet, and charged with sulphantimonite of silver, accompanied by a little native silver. In the more exposed parts the veins also contain chloride and iodide of silver. On the Mariposa estate in the county of the same name, there are upwards of 150 quartz veins, most of them in slates. Some of them are of extraordinary size. One has an average thickness of 12 feet, expanding in places to 40 feet. Another has an average thickness of 20 feet. While others are worked along a line about 70 miles in length; but it is not known whether all the workings are on one and the same vein, although the strike and position of the various isolated exposures render it not unlikely. The auriferous slates of California are of various ages; some are carboniferous, others are oolitic, and yet others are cretaceous.

Although there is considerable similarity in the mode of occurrence of the gold in the two regions, there are some striking differences. In the west, as in the east, the quartz veins are most prevalent in talcose and mica slates; the gold is associated with sulphides of iron and other metals, and is generally most concentrated amidst the most ferruginous parts, or amidst the most drusy and cellular quartz. But the western districts are remarkable for the large size and highly crystalline character of the gold in the veins themselves, for the more frequent occurrence of the veins in granite, and for the predominance of marcasite over iron pyrites. Marcasite is chemically the same as iron pyrites, but it has a different crystalline form.

If we pass to the auriferous veins of Central Europe, such as those of Austria, we find a similarity to those of America in some points, accompanied by differences which stamp them with a distinctive aspect, and indicate that the conditions under which they were formed were similar, but not identical. Thus at Schüttenhofen, Bergreichenstein, Eule, Kattengrund, Tok, and numerous other localities in Bohemia, the auriferous quartz veins traverse gneiss. At Rathhausberg, Sieglitz, and Ober-Vellach, is a quartz vein in the same kind of rock which contains gold, associated with grey sulphide of silver, copper pyrites, galena, mispickel, iron pyrites, and blende. At Bösing in Hungary, auriferous quartz traverses a coarse grained granite. At Kremnitz and Telkybanya auriferous quartz veins occur in trachytic rocks; and at Zalathna, Offenbanya, Nagyag, and other places in the neighbouring district, similar veins have been found in porphyry. Were we to go into details it could be shown that in the Austrian dominions the gold is invariably associated with quartz, or silica in some form, and sulphides, especially those of copper and iron, as in the United States, Columbia, and California; and that although micaceous, talcose, and clay slates are abundantly developed, yet the great majority of the veins are contained in gneiss, granite, trachyte, diorite, and porphyry, in which respect Austria differs remarkably from the various gold countries of North America. This indicates the great caution required in assuming that what is true of one large area, is true for all the rest of the world. Thus Whitney in his 'Metallic Wealth of the United States' remarks that the gold bearing rocks are apparently much the same all over the world. They are generally slaty, talcose, chloritic, and argillaceous rocks. Dana in his 'Manual of Mineralogy' states that gold is mostly confined to those sub-crystalline slaty or schistose rocks that abound in quartz veins, more especially talcose and chloritic slates; that is to those which are imperfectly crystallized rather than the mica schist and gneiss, which are well crystallized. These statements apply to North America, but there are parts of the world to which they do not apply. Thus if we were to arrange the rocks of the Atlantic border of the United States in the order of their importance as gold bearers, the following list would probably be nearly correct:—

Talcose slate.
Mica slate.
Diorite.
Porphyritic aphanite.
Itacolumite.
Gneiss?
Clay slate.
Granite?

Whereas for Austria a precisely opposite order would more nearly represent their importance in that country. In addition to the ordinary veins, Austria possesses another peculiar group. The Carpathian Sandstone of Vöröspatak, Transylvania, is impregnated with gold, and is traversed in all directions by innumerable crevices, sometimes as wide as 2 feet. The gangue of these crevices is a somewhat brecciaform quartz, richly permeated with gold, silver, and auriferous iron pyrites. The quantity of gold is generally increased at the intersection of two crevices. This auriferous quartz forms the minor elevations on the north and south slopes of the Vöröspatak valley, viz., Mount Orla, Vajdoda, Kirniczel, and the Affinien Mountains. Upwards of 200 distinct mines have been opened in it, but the yield is not very large. This sandstone is a lower cretaceous formation. Austria also has an example of what Lieber calls the auriferous beds of the slate. Thus at Zell in the Tyrol, gold is disseminated in certain beds of an argillaceous mica schist, which are distinguished from the other beds by containing a larger proportion of pyritiferous quartz. At Heinzenberg the auriferous bed varies from a few inches to several yards in thickness. The gold, which is rarely visible to the eye, is concentrated in particular layers dipping to the south-west, at an angle of 45°, and separated by sterile zones. Similar layers are found at Rohrberg.

In western Europe there are a group of deposits, which are more properly regarded as stanniferous than auriferous; but we cannot refrain from making some allusion to them here. Under COPPER, E. C. S., reference is made to the way in which the gold and tin ore are accumulated in the gossan by the action of anogenic forces on the various sulphides, and are thereby rendered amongst the most conspicuous metallic products of the districts where they occur. It is known that gold was exceedingly abundant amongst the ancient Gauls, and that tin and copper were also known to them. The association of these metals as being the earliest known is possibly a result of their frequent association in the gossans of western Europe. The brightness and malleability of gold would probably tend to its being first utilised, and would attract attention to the copper and cassiterite accompanying it. Such suppositions at any rate appear plausible in the light of the discoveries made in France during the past few years. In the department of Correze there are numerous veins of cassiterite, which M. Mallard concludes were formed before the carboniferous period. At many places in this department, as at Vaulry, Montebras, St. Leonard, &c., there are traces of numerous shallow excavations, which were manifestly made for the purpose of obtaining both gold and tin ore. There is no record of these mines having been worked, tradition is entirely silent on the subject, and the inhabitants were totally ignorant what were the objects of the excavations until within the last few years. Such at any rate is the testimony of M. Mallard. There is, however, one slight indication showing that the old gold deposit was not quite forgotten, viz., the name Aurières, given to these excavations; but it is said the inhabitants did not know why they were so called. From various considerations it is believed that these superficial diggings were made by the ancient Gauls, whose operations farther south amidst the sands of the Rhone and Ariege will subsequently be noticed. Passing into the department of Morbihan, similar excavations to those of Vaulry have been found at Villeder, near Ploermel, where the industry of the gold-washers and tin-miners is indicated in immense hills of débris and scoriæ, and in the fragments of pottery which evidently formed part of the conduits which conveyed the water to the gold-washings. These also were probably made by Gauls, who have left at least one fine polished stone celt in the alluvium at Villeder. In Cornwall, as is well known, tin-mining or washing commenced in very early times; and it is very probable that the ancient Britons did not neglect the gold which they would meet with. Many of the Cornish families possess gold rings and seals of old date made from the metal obtained from Cornish tin-stream works. The tinners of the present day carry the gold collected by them to Truro to be made into wedding-rings and presents just as the tinners of many previous generations have done; and they put the grains of gold into quills, as Carew reports the tinners of his time did, in the following passage from his 'Survey of Cornwall:'—"Tynners doe also often find little hoppes of gold amongst their owre, which they keep in quils, and sell to the goldsmiths, often with little better gaine then Glaucus' exchange."

Before quitting the British soil, we would allude to the gold discoveries made in Wales during the last decade At a place called Gogofau, a few miles west of Llandovery, veins of white quartz intersect slates belonging to the lower Silurian system. Lofty galleries have been excavated in these rocks; traces of aqueducts, grindstones, and troughs occur in the neighbourhood; and gold has been found on the adjacent Roman station of Cynfil Cayo. Here we have evident signs that centuries ago the Romans had worked these quartz veins for gold. In North Wales similar veins penetrate the Lingula flags near where they merge into the underlying Cambrian grits, at several places near Dolgelly, but chiefly at Cwm-eisen-isaf and Dol-y-frwynog. The slates are traversed by dykes and bounded by large masses of eruptive rocks; and they are frequently altered into a talcose and chloritic schist. The quartz veins contain a great deal of iron pyrites, and are generally composed of white saccharoidal quartz, through which minute, though visible, grains and flakes of gold, galena, copper pyrites, and barytine are disseminated. The lodes appear to be rich in gold in the Lingula flag country only, for whenever they have been followed down into the Cambrian grits, they immediately become sterile or greatly impoverished. Mr. Forbes considers that there is a close connection between the intrusive rocks termed greenstones by the officers of the Geological Survey and the auriferous deposits. In the seven years ending May, 1867, upwards of 12,000 ounces had been obtained from one lode only, viz., that named St. David's, and the yield is still promising.

On turning our attention to the quartz veins of Victoria, we shall find many features in common with those of the other countries which we have noticed, accompanied by others which have not been recorded to exist elsewhere. The veins are most common in the older palæozoic schists, which are generally not highly metamorphosed; but there are also many examples of auriferous veins in the granite. Some of these, as, for example, that at Nuggety Reef, near Maldon, are cut off at the junction of the granite with the slates. The lower palæozoic rocks of this colony consist chiefly of schistose and slaty rocks, in which numerous gold-bearing veins are met with; while the upper palæozoic strata are predominantly sandy, and in them such veins are absent, or, at any rate, rare. There are a few instances of gold in sandstone, diorite, and limestone. The gold of the reef is found to be coarse and more loosely embedded near the surface than at lower depths, where the metal becomes so intimately mixed with the quartz and pyrites as not to be detected by the unaided eye. Near the surface also it is frequently found in clayey and ferruginous masses, filling cracks and hollows. The quartz gold is mostly in hackly grains, and in plates with rugged edges, having an elongated shape and a semicrystalline structure; occasionally they are arborescent and reticulated. Here, as in Carolina, psilomelane is associated with the gold. It occurs abundantly in mammillary crusts and concretions in all the auriferous quartz reefs, and occupies the place usually taken by hydrated peroxide of iron in many of the gold-containing conglomerates. The most remarkable peculiarity of this gold district is the occurrence of the metal in several parallel and horizontal bands of quartz arranged one above another, and extending across dykes of what has been called a syenitic diorite; the rock of which it is composed is a mixture of hornblende and felspar, with a little quartz and mica. They have been met with in several places, as, for instance, on the Werribie river; in the valleys of the Thomson and Latrobe, Gippsland; at Morning Star Hill, &c. In every case the auriferous bands appear to be confined to the more decomposed portions of the dykes, which decomposition is, however, very local and irregular. The following sections (*fig.* 3) of Shakespere Reef, on Gaffney's Creek, represent one of these dykes; 1 being diorite, 2 auriferous quartz, 3 slate, and 4 alluvium.

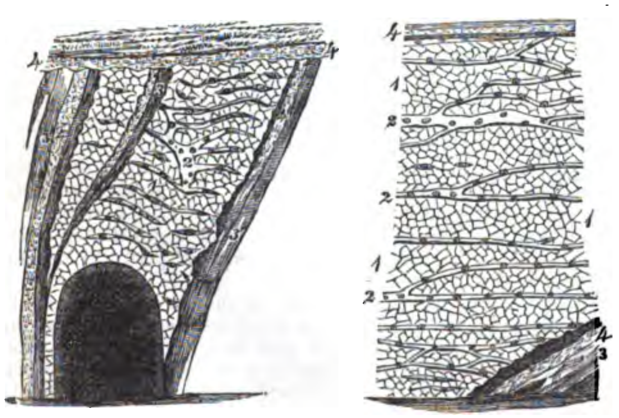

Fig. 3. Shakespere's Reef, Gaffney's Creek, Victoria. The left-hand cut is a cross section of the dyke of diorite along which a tunnel has been driven. The right-hand cut represents one wall of the tunnel about seventy feet from the entrance.

Auriferous quartz-bearing slaty rocks have also been found in New South Wales, Tasmania, and New Zealand, but no detailed description need be given of them, since they present the usual characters, are more or less metamorphosed, and are supposed to be Silurian.

We will therefore proceed to notice the modes of occurrence of gold in drifts and sedimentary strata. These are to be found in or near all the districts where quartz veins are developed, as well as in all the rivers which flow from or through them. It would be manifestly impracticable to give even a list of the localities; indeed it would not suit the object aimed at here, which is to indicate how, rather than where, gold occurs, and to satisfy those who seek for knowledge rather than those who seek for the precious metal. As with the veins, so with the drifts, we shall confine ourselves to comparing those of North America, Europe, and Australia, since they have received a more careful examination than those of other continental areas.

In South Carolina, and in several other States, gravels and clays are found near all the quartz veins, from which they have been derived. In some cases they form small patches of a few acres not many hundred yards distant from their place of origin, in which the fragments are more or less regular, and apparently formed by the washing-down action of heavy rain. Others are of larger superficial extent, have been transported from greater distances, and consist mostly of rounded fragments, indicating that the rivers may have assisted in their distribution. In most cases the gold is found in the hyaline and opaque quartz pebbles, as well as in the white pipeclay; and it is an interesting fact that the particles of metal in the clays are perceptibly larger than the particles in the veins to which the gold may be traced. The reddish clay of North Carolina is said to be rich in metal. It forms the principal soil of the State, and is formed from the decomposition of diorite. Farther north, or in Canada, the superficial auriferous clay deposits are developed on a larger scale. According to Dr. Sterry Hunt, they cover all the country comprised between the St. Francis and Etchemin rivers, on the south side of the St. Lawrence, and from the first range of hills to the south-eastern boundary of the province. They not only occur in the river beds, but under such circumstances as to show they were laid down before the present river valley was marked out. The gold is in grains, which are sometimes angular, but more frequently rounded; and are associated with magnetite, chromite, hæmatite, ilmenite, garnet, zircon, rutile, and corundum. On the Magog river gold occurs in gravel 156 feet above the present level of the St. Francis. Along the banks of the Famine and Metcalfe rivers is a stratum of clay overlaid by sand and gravel. The spaces between the pebbles forming the uppermost six inches of the gravel are filled with oxides of iron and manganese. Gold occurs both in the gravel and in the clay. Large areas of country in Vancouver's Island, British Columbia, and California, are also covered with similar clays and gravels; and as it is probable that throughout this district all the gravels were formed under somewhat similar conditions, it will suffice if we notice one gold field, viz., that of California. The quartz vein bearing granites and metamorphic slates already alluded to, form the borders and bottoms of valleys which are more or less filled with detritus, lava streams, and stratified layers of volcanic ashes. The gold occurs almost everywhere, from the Tejon Pass to beyond the northern limits of the State, but is perhaps most abundant in the counties of Mariposa, Tuolumne, Calaveras, Amador, El Dorado, Placer, Nevada, Sierra, Plumas, Yubas, and Butte. In the more northern of these counties the auriferous gravel occupies the hollows and old river valleys of the country during the pliocene period, when the system of drainage was entirely different from that which now exists. Above this, sands and clays, with occasional bands of lignite, have been deposited, followed by thick beds of volcanic ashes, while, capping all, is a thickness of upwards of 100 feet of compact lava. Since the flow of the lava the country has been subject to much denudation, so that now the rivers flow through deep ravines or caverns, the hills bounding which are surmounted by the hard weather-resisting lava. The consequence is, that the old gravels are situated near the summit of the present hills. A section of the Table Mountain (*fig.* 4) is a

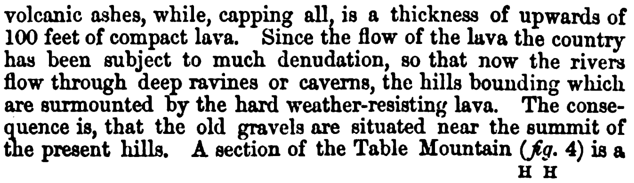

Fig. 4.

good illustration of this condition of things. The valley in which the gravel was deposited and down which the lava flowed, is conjecturally indicated by the dotted lines; *c c* shows the position of the auriferous gravels, which are described as being like the coarse gravel formed in ordinary river beds; the horizontal black line is a tunnel driven for the purpose of getting at the gravel; *s* is sandstone; and *l* is the sheet of lava. The present conformation is shown by the continuous outer lines. The process commonly adopted for washing these gravels is exceedingly interesting from an industrial point of view. Immense sums of money are spent in constructing canals of unusual magnitude. More than one large river is entirely used up by the gold-washers, who direct strong currents of water against the strata underlying the lava, and thus wear away the hills in order to get at the gold. The auriferous drifts of Ecuador occur in similar situations.

The gold-washings of Austria are numerous. The older ones occur along the river Wattowa and its affluents; and others are situated at Eule, in Bohemia; at Linz, near Salzbourg; along the Ticino river in Lombardy, where the gold is associated with magnetite, garnet, hyacinth, &c.; in the valley of the Csermek; along the Theiss river, from its source to Tirza Ujlak; and along the Maros, especially near Olahpian. This last district is about two miles long and one wide. It is formed of mica schist supporting sandstones and conglomerates. Upon these rest the sands, gravels, and clays forming the auriferous district proper. It is remarkable that the sands on the crests and peaks of the ranges of hills are alone auriferous, while those in the valley bottoms show no signs of gold.

In France gold has been discovered in the department of Gard in a conglomerate which forms part of the coal measures. The conglomerate is composed of pebbles of quartz and mica schist embedded in an argillaceous schistose matrix or cement. The metal occurs in the matrix only, and is associated with zircon and the garnet. The sands and alluvial deposits of the Gagnere and Ceze rivers derive their gold from this source. Round about St. Ambrose are numerous evidences of the old workings made by the Gauls, in the material re-deposited on the flanks of the hills and the surfaces of the plateaux. These deposits were worked during the middle ages, and with the sands of the Rhine, Rhone, Ariège, and other rivers, formed the California of the period, which has been almost deserted since the discovery of America by Columbus. A few gold-washers may, we believe, still be found plying their trade along the Ariège, a name which, originating in the *aurigera*, or 'gold-bearer' of the Romans, the river continues to deserve.

The auriferous alluvium of Victoria gives employment to more than 60,000 individuals, who obtain upwards of a million ounces of gold annually. The deposits containing the gold are of various ages, but all are said to be of more recent formation than the miocene epoch. Here, as in California, the surface of the land before the deposition of these deposits was not the same as it is now. The old valleys and hollows have been filled up by gravels, sands, and layers of volcanic matter; denudation has remodelled the surface thus produced, but the alteration has been far less here than in California. The auriferous drift occupying the old rivers, channels, and valleys, which are called *leads* and *gutters* by the miners, is sometimes hundreds of feet below the ordinary level of the present surface, while sometimes it is found in the interior of hills and at a height of 60, 70, or more feet above the level of the present watercourses. The gold in the latter is sometimes obtained by washing away the less compact strata by means of the hydraulic process, or by driving tunnels into the hill. The auriferous earth consists of quartz, gravel, sand, and clay, in which the gold occurs in grains, scales, and nuggets. The following quotation from a paper by Messrs. Selwyn and Ulrich, in the official record of the Intercolonial Exhibition of Australasia (1867), expresses the opinions of the Victorian geologists on the auriferous drifts. "No beds whatever containing marine fauna are known in Victoria overlying alluvial or drift gold deposits. That there are rich gold drifts, the result of at least three distinct periods of deposition, is quite certain, and it is now almost equally certain that the earliest is not older than the pliocene, while the newest is probably chiefly due to causes still in operation. In accordance with this view, and for the sake of convenience, these three auriferous deposits have been provisionally classed as older pliocene, newer pliocene, and post pliocene (including recent), or lower, middle, and upper drifts, coloured respectively on the geological maps [of the Victorian Survey], yellow, red, and green; the same classification and colouring have been used to denote deposits, whether marine or fresh water, supposed to belong to the same age, though not auriferous or derived from auriferous rock. The three stages of drift sometimes occur in the same locality, without the intervention of any volcanic rocks, in which case three auriferous 'bottoms' or gold-bearing strata are found in one shaft. In some instances, as in the Ballarat valley, the oldest auriferous formation is made up of successive layers of volcanic and sedimentary material that gradually fill up the old valley and overlap each other, forming gold drift deposits or 'washes' at various elevations, which are certainly not the result of purely fluviatile action. In following the 'leads,' they are invariably found to deepen in the general direction of the present surface watershed. Thus at Ballarat and other gold fields on the south side of the dividing range they deepen in the opposite or northerly direction. This fact has given rise to the supposition, manifestly absurd, that the Ballarat and other deep 'gold leads' will have a continuous fall till they eventually reach the present sea coast, in the same manner as existing surface drainage channels." It is conjectured that these old channels terminate along a line where the old slates are now between 600 and 700 feet above the present sea level. In some parts of the colony there are some older gravels which Mr. Selwyn concludes from stratigraphical evidence are older than the middle miocene beds; and he further states "that they do not probably contain gold in paying quantities, because, as I believe, they are derived from the abrasion of quartz veins, that themselves contained little or no gold, and that they were probably formed by forces in operation as long prior to those which produced the gold-bearing veins as the denudations producing the barren miocene gravels were prior to those which gave rise to the pliocene productive ones." Both conclusions may be accepted so far as they concern the particular drifts referred to, but further evidence seems to be required before admitting the correctness of the conclusion that all the miocene gravels of Australia are non-auriferous, or that all the productive quartz veins in the older rocks have been formed since the miocene epoch, and all the non-productive ones before that period. Gold has been found, although in minute quantities only, in the cement of a carboniferous conglomerate at Wingelo, St. Leonards, and other places; in quartz pebbles in some of the secondary rocks of Queensland; in a coal seam in Tasmania; and in the alluvial deposits of the river Waimangaroha in New Zealand, whose bed is restricted to carboniferous rocks throughout its whole course.

There are many other cases of gold disseminated in palæozoic strata. Thus it is found in the carboniferous conglomerate of Nova Scotia; and we believe also in a Silurian gneiss of Venezuela. Gold occurs under remarkable circumstances in South Carolina. Amongst the lowest rocks there developed, are some partially vitrified granular quartzites, overlain by sandstones and quartzites. They are crowded with lenticular bodies which Emmons regards as corals, and has hence given them the generic title of *Palæotrochus*. They are associated with numerous siliceous concretions. The debris of the fossiliferous sandstone, which is supposed to belong to the Potsdam series, has been worked for gold, which is concentrated in ferruginous patches, which appear to have originally been auriferous pyrites. This fact is so interesting and important, that it would be desirable to have more detailed information respecting it. The first question that requires answering is whether the ferruginous matter is contemporaneous with the sandstone or of subsequent introduction; next, is there any probability that the auriferous ore has been formed *in situ* at a comparatively recent period, or has it been introduced from without. If it appears probable that the ferruginous ore is as old as the formation in which it occurs, we have here an important fact in favour of the antiquity of gold, and of its occurrence in Silurian or pre-Silurian sedimentary rocks.

In connection with this part of the subject we may refer to the opinions of Mr. D. Forbes on the appearance of gold in the earth's crust. "My researches," says he, "have led me to conclude that, universally, gold has been introduced into the crust of the earth at two very distinct geological epochs, and that in both these cases it has been carried up in direct consequence of, and in conjunction with, the outbursts of distinct and characteristic plutonic rocks. These two epochs of auriferous impregnation I designate respectively as (1) the older or auriferous granite outburst; (2) the younger or auriferous diorite outburst. (1). The older or auriferous granite intrusion, appears to have occurred at some time between the lower Silurian and carboniferous period; certainly not older than the upper Silurian or younger than the carboniferous; probably not younger than the deposition of the first members of the latter formation. Gold formations belonging to this period present themselves in Australia,* [the asterisk indicates that deposits belonging to the newer formation are also found in the country against whose name it is placed], Bohemia, Bolivia,* Brazil, Buenos Ayres,* Chile,* Cornwall, Ecuador, Hungary, Mexico,* New Granada, Norway, Peru,* Sweden, Ural,* and Wicklow. To this period and cause I also attribute most of such deposits of gold as are found intruded as quartz nodules and veins in many places, as if interstratified in the Cambrian and Silurian (and probably also Laurentian and Devonian) systems, which, I believe, to have arisen and been rendered auriferous solely from the proximity to invisible or non-superficial granites. (2). The newer or Dioritic outburst I have called Post Oolitic, as the veins containing gold, and which proceed from its centres, cut through strata containing fossils of decided post-oolitic forms, and possibly may be as late as early cretaceous. These strata are frequently much altered and metamorphosed by the contact of the igneous diorite, and at such points often become auriferous, or are cut by auriferous veins proceeding from the diorite head mass." Mr. Forbes believes auriferous rocks of this age to exist in Italy and India, in addition to the countries already mentioned.

Sir Roderick I. Murchison, in an admirable essay on gold forming part of his 'Siluria,' also advocates the igneous origin of the metal. His main conclusions are—(1) that, looking to the world at large, the auriferous veinstones in the lower Silurian rocks contain the greatest quantity of gold; (2) that where certain igneous eruptions penetrated the secondary deposits, the latter have been rendered auriferous for a certain distance only beyond the junction of the two rocks; (3) that the general axiom before insisted on remains, that all secondary and tertiary deposits (except the auriferous detritus in the latter), not so specially affected, never contain gold; (4) that as no unaltered purely aqueous sediments ever contain gold, the argument in favour of the igneous origin of that metal is prodigiously strengthened; or, in other words, that granites and diorites have been the chief gold producers, and that the auriferous quartz bands in the palæozoic rocks are also the result of heat and chemical agency.

Our own opinion as to the mode of formation of auriferous veins may be deemed of little value as compared with those of the eminent authorities just cited, but as it differs from theirs, we will state it. The predominant facts connected with gold are, that it is intimately associated with silica, iron pyrites or other sulphides, and rocks of the nature of clay in a more or less altered condition. The veins themselves appear to be connected in some way with volcanic or plutonic rocks. Our impression is that the surface water percolates downwards, reaching depths at which they become hot springs; that in this state they ascend, dissolving the iron pyrites, silica, and gold they meet with in the argillaceous rocks to re-deposit them in the fissures up which they are carried. And that these warm springs are most abundant during the time when volcanoes are in an active state and in their neighbourhood.

Gold crystals are rare. The majority of them are found in the drifts; a circumstance which it has been suggested is not surprising if we consider that the gold from the drift was at one time distributed through far more rock than has ever been crushed. Some of the finest crystals and crystalline masses are those found in California. One found at Forest Hill in Placer County was an imperfect octahedron, in which the facets were made up of planes lying like plates one within the other. It was elongated and distorted so as to have the appearance of a rectangular octahedron. The length of the larger base was 1 inch, and of the shorter ⅞ of an inch. In the same county masses have been found so shaped, veined and reticulated, as to present considerable resemblance to the fronds of golden ferns. Thus one specimen is described as having the form of a leaf; one side of which is beautifully arborescent, while the other is studded with 25 perfect octahedrous geometrically arranged, and having all their similar sides parallel to one another. It weighed 17 dwts. 10 grains; and measured 2¼ inches by 1½ inches. A remarkably large specimen, 12 inches by 4 inches, was partly composed of a smooth plate about 4 inches in length, with its surface covered with triangular markings, and partly of an arborescent portion. All these were found in the drift. In Australia also small crystals are found in all the gold fields, generally near the surface of the drift, and more especially in the vicinity or in the upper portion of the quartz veins. They are found in those parts of the veins where there has been most alteration and oxidation, while the gold found in the compact part of the veins is, as we have already noticed, almost invariably in scales, or particles, with a rough and rugged exterior. Dr. Genth has particularly noticed that the gold in the decomposed diorite of North Carolina is smooth and rounded as though water-worn, but its position precludes the supposition that water or attrition can have produced the effect. Moreover, the crystals in cavities in the massive gold also present the same appearance. Hence he suggests that the roundness has been produced by a solvent; an idea which receives much support from various sources. Thus, at the Whitehall Mine in Virginia, gold is crystallised on tetradymite in forms belonging to the rhombohedral system, such as belong to tetradymite itself; a fact which shows that the gold has taken the form of tetradymite. At Springfield in Maryland the cleavage planes of the magnetite are coated with films of gold. Dr. Genth also refers to a specimen which consisted of greyish white crystalline quartz containing minute traces of crystallised quartz, and aikinite. Most of the aikinite had been converted into cuprous carbonate of bismuth in slender needles. In many cases the centre of these was occupied by bright yellow gold having the rhombic form of the original aikinite. All these changes point to the existence of natural solutions. On cutting gold crystals in half they are generally found to have a nucleus of quartz, iron pyrites, or of brown iron ore, which last is formed from iron pyrites by the action of oxygen. It has often been noticed that where trees grow upon auriferous quartz veins the roots are frequently coated with gold. These facts also suggest the existence of gold solutions, for it is known that tetradymite, ferrous salts, organic matters (such as chips of wood or bark), many metals, such as copper, iron, and many metallic sulphides, such as arsenical pyrites, galena, zinc blende, molybdenite, will precipitate gold from its solutions.

The aggregation of small particles into larger particles and into nuggets receives a ready explanation on the supposition that there are natural gold solutions. We have already cited several instances of the gold particles being larger at the top of the decomposed part of the vein than at the bottom, and in one case we referred to the fact that the larger particles were purer than the smaller, even in the same vein. Many gold-washers know that an old tailing may be washed repeatedly without appearing to diminish in richness, provided sufficient time be allowed to elapse between each washing. Something similar occurs in the gold-bearing sands which form the beach along 80 miles of the Californian shore. When this sand has been washed until scarcely any more gold can be got out of it, the claim is rendered as rich as ever by the action of a storm. In the same way, as the larger particles differ from the smaller ones in the Dorn mine, so we find nuggets differing from quartz gold. Not only are they larger, but they are considerably purer—a remark which applies to all drift gold.

(Whitney, *Metallic Wealth of the United States*; Logan, *Geology of Canada*, 1863; Nickles, *Comptes Rendus*, tome 63; Faraday, *Philosophical Transactions*, 1857; Lieber, *Reports on the Survey of S. Carolina*; Whitney, *Geology of California*, vol. i.; Blake, *American Journal of Science*, Second Series, vol. xx.; Haidinger, *Coup d'Œil sur les Mines de la Monarchie Autrichienne*; Simonin, *Comptes Rendus*, tome 62; Mallard, *Comptes Rendus*, tome 62; Genth, *American Journal of Science*, Second Series, vols. xxviii. and xxxiii.; De la Fosse, *Nouveau Cours de Mineralogie*; Clarke and Selwyn in the *Geological Magazine*, vols. ii. and iii.; D. Forbes, *Geological Magazine*, vol. iii.; Clarke, Selwyn, Ulrich, and Bleasdale, *Intercolonial Exhibition Essays*, 1866, 1867; Marsh, *American Journal of Science*, Second Series, vol. xxxii.; Murchison, *Siluria*, fourth edition.)

GOSSYPIUM [E. C. vol. ii. cols. 1077—1080, and COTTON, E. C. vol. ii. cols. 172—174]. The appearance of cotton fibre as described under the last-mentioned article is correct, so far as it concerns the dried fibre when worked up into goods; but the remarks there made do not fairly represent the structure of the growing fibre. In the earliest stage the cotton hairs appear on the surface of the seed-pod as minute semi-transparent protuberances very similar to those on the stem and leaves of the ice plant. A few motionless granules make their appearance in the hairs, and as these lengthen the granules and the mucus-like fluid in which they float acquire a distinct rotatory movement like that observable in the cells of *Nitella* and numerous other genera of plants. In a later stage the granules are smaller, more numerous, and the mucus in which they float has acquired a pale buff colour. As the plant continues to grow the contents of the hairs increase in density, the rotation of the granules slackens, and, as is believed, ceases in about a fortnight after the hair has commenced to grow. In the mature and healthy pod the hairs have their walls thickened by a secondary deposit, and their interior partially filled with a granular substance. The secondary deposits on the cell wall render the hair luminous under polarized light. There are no signs of any spiral fibres in the growing fibre, and unless bruised or crushed, the transverse section presents a circular outline. Many microscopic observers have maintained that the fibre is flat, moniliform, and that it contains a spiral vessel or thread. The estimate of the number of turns of the spiral per inch has varied considerably, from 1500 to 50,000. These appearances are probably due partly to the fibre being dried, partly to the treatment which it has received in the cotton manufacturer's hands, and partly to the application of solvents for the purpose of developing the structure of the fibre. At any rate, this seems to be the conclusion to which one is led by Mr. Dancer's experiments on cotton. After referring to the twisting of cotton under the influence of an ammoniacal solution of copper, he states that "the explanation which I have to offer for the phenomenon is this: first, we have the external membrane of the cotton; then the cellulose and primordial utricle; and, finally the dried contents in the cell, which I take to be the remains of the organizing fluid. Observation shows that the external envelope is not elastic, and only partially soluble. The cellulose is exceedingly elastic and soluble, and expands to a remarkable degree in the act of dissolution. The contents of the cell behave in a similar manner to that of the external membrane; it is neither elastic nor very soluble. The most successful experiment is made by allowing the copper solvent to come into contact with some length of the cotton hair. The solvent permeates some parts of the external membrane more easily than others, and causes a rapid expansion of the cellulose, which bursts the external membrane; and as this action is taking place at various portions of the same hair, a tangential force is excited which twists and contorts the cotton in the direction of its length, and thus a spiral appearance is given to the whole structure of the cell. The non-elastic external covering is twisted round the expanded cellulose, sometimes as a single band, at others like a bundle of fibres. In those parts where the external covering has given way all round the hair, the cellulose expands into a bulb, pushing back the external membrane into a series of folds which form a ligature, and resists the expansive force of the cellulose. A number of these ligatures cause the expanded cellulose to assume the appearance of a string of beads. The lateral expansion of the cellulose contracts the length of the hair, and this causes the contents in the cavity of the cell to assume a corrugated appearance; this corrugation has also been subjected to the twisting power along with the other parts of the cell, and thus its spiral appearance is produced." These observations are important, as indicating a difference in the physical and perhaps chemical nature of the cellulose and the membranes on either side of it, and they suggest that the spiral appearances in other fibres, such as those of flax and hemp, may be induced by similar causes.

The weakness and flatness of cotton is by no means so excessive as might be supposed from the description under Cotton, E. C. S., which appears to be based on the worst samples. The best samples have a large proportion of cylindrical and slightly flattened fibres, which develope bright colours in polarized light; the inferior cottons are twisted, tube-like, and pale when viewed under the polariscope. The strongest fibres will sustain an enormous weight relatively to their own; thus in one case Mr. O'Neill, of Manchester, found that a fibre of Orleans cotton, which weighed less than the ten thousandth part of a grain, supported 162 grains without breaking.

GRANITE. The origin and mode of formation of this rock is still a matter of keen discussion. According to some it has been ejected in a fluid state from the interior of the earth; according to others it is a rock in situ rendered semi-fluid and plastic by hydrothermal agencies; while yet others believe it to have been first derived by degradation from pre-existing rocks, then stratified, and subsequently altered and consolidated, mainly by prolonged action of water and pressure, combined with a very moderate degree of heat.

Granite is a mixture of felspar, quartz, and mica, having a crystalline-granular structure in which felspar is by far the most predominating ingredient; in addition to these it may contain small quantities of other minerals, which may in some cases become sufficiently abundant to mark varieties. Granite and gneiss are identical in composition, but are markedly different in their texture and appearance when typical specimens are compared. The former is massive, its particles are never arranged in regular layers, and its structure is exceedingly compact and crystalline. When, however, a large series of specimens is examined, or when the rocks are studied in the field, there is no definite line of demarcation between granite and gneiss, since the one merges into the other by almost imperceptible gradations.

The felspathic ingredient of granite is chiefly orthoclase (a potash felspar), generally accompanied by a small proportion of oligoclase (a soda felspar). The colour of the orthoclase is generally a yellowish white, a reddish white, or a flesh red, and less frequently it presents light tints of green, blue and grey. As it forms the greater bulk of the rock the colour of the granite generally indicates the colour of the felspar. Its lustre is pearly white, that of oligoclase is resinous and frequently dull; its exposed surfaces are less marked with parallel striæ than are those of oligoclase. The quartz occurs rarely in well defined crystals, but generally in irregular granules, which may be at once distinguished by their greyish colour, their vitreous lustre, their semi-translucency, and their hardness. In some rare cases its colour is yellowish or blue, as in the granite of Rumberg, in Bohemia; or red, as in the granite of Jagerthal, in the Vosges mountains. The mica is the least important of the three principal ingredients; it is generally the potash mica, which is sometimes accompanied by the iron-magnesia mica, and more rarely by the lithia mica. Their crystals are generally hexagonal plates, scattered irregularly through the rock, or collected into nests; they are seldom very large. The iron-magnesia mica is generally of a brown-black, or somewhat greenish tint, and is also found in many other rocks, such as trachyte, dolerite, and lava; but the mica of granites is distinguishable from the mica of other rocks by certain minor peculiarities. Thus it occurs in thick plates as well as in thin flakes; its colour is very deep, and its lustre is strongly developed. The potash mica, or muscovite, is generally white, and pearly-lustred; it is probably never found in lava and other rocks which are known to have been solidified from a fused state.

In most granites the constituent grains are pretty nearly of the same size, but in some cases one or other of them will form exceptionally large crystals, giving rise to the porphyritic structure. Thus the felspar sometimes appears in large well-shaped twin crystals several inches in length, which in nearly every instance belongs to orthoclase. These crystals are sometimes found broken across, and the parts slightly separated. There is more or less variation in the proportions of the principal ingredients even in the same mass of granite; while some varieties are so poor in mica that they seem at first sight to be aggregations of felspar and quartz only.

The accessory ingredients of granite are numerous. In some cases one or two of them become so abundant as to form a distinct variety of granite, and when this is accompanied by a diminution in one or more of the principal ingredients of the granite, transitions are presented to other kinds of rocks. Amongst the more important accessory ingredients may be mentioned chlorite, talc, hornblende, micaceous iron, graphite, tourmaline, garnet, topaz, beryl, pinite, fluorspar, apatite, magnetite, cassiterite, iron pyrites, molybdenite, corundum, zircon, pistacite, titanite, gadolinite, orthite, pyrorthite, allanite, cordierite, andalusite, arsenical pyrites, gold, and probably water together with organic matter. The presence of chlorite and talc forms a transition into protogene; that of tourmaline or schorl into schorl rock; that of hornblende into syenite; that of graphite gives rise to graphite granite; and the micaceous iron gives rise to ferruginous granite. By the gradual diminution of quartz it passes into mica trap; while the disappearance of the felspar leads to greissen, and that of the mica to aplite or granulite. These variations and transitions are, as may be supposed, exceedingly numerous, and it has been convenient to give those which are most marked distinct names. They form the family of granites, and will be described in the article Granitic Rocks, E. C. S.

In the present state of our knowledge chemical analyses will not enable us to judge even approximately what is the lithological composition of rocks, more especially of such as contain nearly the same elements as granite. As, however, they indicate what the rocks are made of, and have a bearing on the hypotheses respecting their origin and past history, a few details on this branch of our subject may be useful.

Arranged in the order of their abundance the minerals in granite are felspar, quartz, mica, &c. Of the two felspars, orthoclase is always the most predominant; while of the two micas, the potash mica is generally the most abundant. The composition of these minerals is shown in the following table; the upper series of analyses represents the theoretical composition of the pure minerals, while the lower represents the results obtained from actual specimens. As the micas are exceedingly variable in their composition, we have selected theoretically pure ones which come nearest the composition of the micas generally met with in granite.

	Orthoclase.	Oligoclase.	Muscovite av.	Black mica.	Quartz.
Silica	64·8	62·8	44	41	100
Alumina	18·4	23·1	37·1	22·7	—
Potash	16·8	—	18·8	—	—
Soda	—	14·1	—	—	—
Lime	—	—	—	—	—
Magnesia	—	—	—	—	—
Oxide of iron . .	—	—	—	35·5	—
Oxide of manganese	—	—	—	—	—
Water and loss . .	—	—	—	—	—
Silica	63·60	59·28	44·80	36·20	100
Alumina	19·32	22·96	29·76	15·95	—
Potash	13·55	2.38	12·44	8·65	—
Soda	1·84	6·48	·32	·16	—
Lime	·72	4·65	·45	·50	—
Magnesia . . .	·14	·21	·71	5·00	—
Oxide of iron . .	·80	2·04	8·80	27·83	—
Oxide of magnesia .	—	·32	·48	1·50	—
Water and loss . .	—	—	2·00	3·90	—

In the next table a few analyses of granites are given :—

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Silica	70·0	69.36	73.60	73·13	69·31	62—81
Alumina	16·36	16.00	13·80	12.49	16·40	10—17
Potash	4.66	4·47	5.22	4.13	2·87	·4—5
Soda	4·13	4·17	4·29	2·61	3·29	·1—5
Lime	1·12	2·29	·79	2·40	3·06	·7—3
Magnesia	·71	.54	·50	·27	·83	·1—2
Oxide of iron . .	2·88	3·33	2·00	2·58	4·30	—
Oxide of manganese	—	—	—	.57	·03	—
Water and loss .	—	—	—	·53	·84	·4—2

No. 1 is a coarse-grained granite, from Ardmalin, in Donegal, Ireland. It is composed of quartz, red orthoclase, and green mica. No. 2 is a coarse-grained porphyritic granite from Glenveagh, in the above-mentioned county, composed of pink orthoclase, grey quartz, and jet-black mica. No. 3 is a coarse-grained reddish granite from Barnesmore Gap, Donegal, and is composed of grey quartz, red felspar, and green mica. No. 4 is a granite from Strigau, in the Riesengebirge, composed of orthoclase, quartz, oligoclase, and magnesian mica. No. 5 is a granite from Meerange, in the Central Carpathians, composed of orthoclase, oligoclase, quartz, magnesian mica, and potash mica. And No. 6 shows the range of the various chemical compounds in granite according to Roth. Typical granites, however, it should be remembered, never exhibit so wide a range.

In the next table is indicated the composition of granites supposed to contain certain given proportions of the primitive ingredients, in order that the effect produced by increasing or decreasing each of them may be seen. The constituents are supposed, for convenience sake, to have the composition represented in the lower part of the first table.

	(1.)	(2.)	(3.)	(4.)
Silica	74·69	72·04	71·05	70.2
Alumina	12·61	14·44	14.55	15·5
Potash	7·2	9·08	8·48	9.23
Soda	1·11	1·52	1·17	1·38
Lime	·58	·72	·64	·68
Magnesia	·38	.2	·38	·41
Oxide of iron . .	2·69	1·2	2·77	2.71
Oxide of manganese	·13	·05	·13	·13
Water and loss .	·4	·1	·4	·4

In No. 1 the proportion is 40 per cent. of orthoclase, 5 of oligoclase, 40 of quartz, 10 of potash mica, and 5 of the ferro-magnesian mica. In No. 2 there is supposed to be 63 per cent. of orthoclase, 6 of oligoclase, 27 of quartz, 3 of potash mica, and 2 of ferro-magnesian mica. In No. 3 there is 50 per cent. of orthoclase, 5 of oligoclase, 30 of quartz, 10 of potash mica, and 5 of ferro-magnesian mica. In No. 4 there is 55 per cent. of orthoclase, 5 of oligoclase, 25 of quartz, 10 of potash mica, and 5 of ferro-magnesian mica. The reader must not attach too much importance to these figures, as they are intended simply as rough indications of what may have been the composition of certain granites. In order to fully appreciate the results produced by variations in proportions, a far more extensive ringing of changes would be required not only on the principal ingredients, but also on some of the accessory substances.

GRANITIC ROCKS. The granitic group of rocks embraces the large proportion of those which are most highly crystalline, and most highly silicated. They have a general resemblance in the elements which compose them, but differ from one another by their greater or less degree of crystallization, the relative sizes and proportions of their constituents, the mode in which these constituents are arranged, and other points. As these differences are only differences of degree, not always well marked, it seems better to notice the group under one heading, rather than to scatter the separate rocks under different headings.

Gneiss.—An aggregation of felspar, quartz, and mica, having a foliated, and sometimes a cleaved structure. The felspar is generally orthoclase, which may sometimes be accompanied by oligoclase, and more rarely by albite. The orthoclase is always the prevailing felspar; its colour is white, light gray, yellowish, or reddish; its cleavage faces are smooth, and pearly lustred. The oligoclase has a duller lustre, and its cleavage faces are marked by parallel striæ. The quartz is whitish or greyish; it sometimes occurs in lenticular lumps, but is generally so mingled with the felspar as to form a regularly granular mass. The mica is grey, brown, or black in colour. It is either the potash or magnesia mica, the former being the most general, while occasionally both occur in the same rock. The accessory ingredients are very numerous; but the more important are chlorite, talc, hornblende, micaceous iron, graphite, tourmaline, garnet, magnetite, iron pyrites, zircon, pistacite, andalusite, kyanite, rutile, and titanite. The varieties of *Micaceous gneiss*, or *gneiss* proper, as distinguished from hornblende gneiss or protogine gneiss, are mainly characterised by the degree to which foliation is developed, which for the most part depends upon the quantity of mica, being more distinct in proportion as the mica is more abundant. Sometimes the flakes are isolated, sometimes they are collected into little groups, and sometimes they form a continuous lamina. *Granular fibrous gneiss.*—The mica forms isolated and well-developed crystals, which in places are arranged in parallel layers, alternating with the felspar and quartz. *Granular streaky or granitic gneiss.*—The mica occurs in small flakes, but in such small quantities that the foliated structure is scarcely perceptible. When the flakes are very small, the rock has an aspect almost like granite. It occurs at Sageritz, near Grossenhain; Boxdorf, near Moritzburg; Brambach, in the Voigtland; and Höfles, near Eiger. *Streaky Gneiss.*—In this variety the mica occurs both abundantly and of considerable size; it is arranged in layers, which are undulated and swollen in places, so that when a section is viewed the mica appears to be grouped in lines of wedge-shaped clumps. As the mica is not arranged quite symmetrically, these clumps are very unequal as regards the proportion between their length and breadth, so that some appear as long narrow streaks, and others as short broad ones. Combined with this are various differences in the mass of the rock, which may be fine, medium, or coarse grained, and sometimes the felspar may occur in large well developed crystals, giving rise to a porphyritic texture. When the above arrangement of mica is most marked, the rock acquires a woody, banded, ribboned, or even asbestos-like appearance, and is then known as *coarsely fibrous gneiss, or hölzgneiss.* It occurs near Weissenborn, and a few other places in Saxony. *Slaty gneiss.*—The mica occurs in continuous layers, which alternate with the fine-grained matrix of the rock. When cleaved, the mica only can be seen on the surfaces so obtained. *Cornubianite* is a fine-grained gneiss, which is generally associated with granites. The felspar, quartz, and mica are so exceedingly mingled and interwoven, that the foliated structure is only indicated by bands varying in colour, and the degree of fineness of grain. They are generally tinted with dingy shades of green, yellow, and red, banded with brown or dark green stripes. At the parts furthest away from the granite they have a more or less distinct cleavage. It occurs in the Saxon Erzgebirge, in various parts of the Alps, and in Cornwall. The foregoing varieties are based upon differences of structure; but those we are about to mention are based on differences of composition, and form the connecting links between gneiss and other rocks. When the mica is more than usually abundant, the rock acquires a fine foliated structure, and approximates in character to mica schist. This variety may be seen at Gastein, in the Alps, and near Rabenau in Saxony. When the mica is more than usually scanty, as near Freiberg, Marienberg, and elsewhere, it is called *granulite gneiss*, and approaches granulite in character, which rock may be regarded as a gneiss, with very little mica. There is a gneiss very rich in quartz, but there do not appear to be varieties characterised by a small proportion of quartz. Schists are, for the most part, varieties of gneiss containing little or no felspar. The next group of varieties is based upon the greater or less replacement of the ingredients of typical gneiss. *Protogine gneiss.*—It is widely distributed through the Alps, and consists of white or reddish lustrous orthoclase, mingled with a little dull greenish-white oligoclase, a light-coloured quartz, a dark green ferruginous mica, and a mineral resembling chlorite, which replaces a portion of the mica. The mica occurs in small flakes, very sparingly distributed through the rocks; while the felspar and quartz are blended together into a finely granular aggregate. The foliation is indistinct, but the cleavage is generally well developed. *Dichroite gneiss* has the mica more or less replaced by dichroite. In the *micaceous iron gneiss* of Fichtelgebirge, and the *graphite gneiss* near Passau, on the Danube, the substances from which they take their names are the substitution products for the mica. In *Adularia gneiss* the prevailing felspar is Adularia, and in *oligoclase gneiss*, the mineral indicated by its name. This last enters largely into the composition of Adam's Peak of Ceylon. There is still another group of varieties depending upon the more than usual abundance of one or more of the accessory ingredients of ordinary gneiss, principally garnet, tourmaline, pistacite, or iron pyrites.

In *hornblende gneiss* the ingredients are felspar, quartz, and hornblende. Its structure is usually granular streaky, and its constituents are highly crystalline. Its accessories are the same as in ordinary gneiss, and it is generally arranged with this gneiss in alternating thick bedded layers. It is sparingly developed in Germany, but is abundantly displayed in France, Scandinavia, Scotland, and North America.

Halleflinta is a rock which should perhaps be ranked with gneiss. It is composed of a mixture of felspar and quartz, so intimately blended together that a chemical analysis is required to detect them. There is also a considerable proportion of chlorite, which frequently imparts a green colour to the rock, while mica and hornblende are present in subordinate quantities only. Its foliation is indicated by bands of colour, which may be either grey, green, yellow, brown, or black. Cleavage is seldom well marked, but the more compact varieties are usually more or less traversed, and split up into irregular cuboidal lumps by joints. It is generally associated with the oldest gneiss formation, as between Upsala and Dannemora in Sweden, and the island of Utoe. This rock is intermediate between the more compact varieties of common gneiss and felspar porphyry.

The result of a chemical analysis of the rocks of the gneiss group has led Scherer to propose their division into three sections. 1. Red gneiss or gneissite (as Cotta terms it) contains orthoclase as the only felspathic ingredient, which is generally reddish, and exceptionally white or grey; the mica is light-coloured, and forms only about 10 per cent. of the rock; and the proportion of silica is between 74 and 76 per cent. 2. The grey gneiss, which contains a little oligoclase and albite accompanying the orthoclase, and whose colour is generally white or grey, rarely reddish; the mica is dark-coloured and forms 30 per cent. of the rock; and the percentage of silica varies between 64 and 67 per cent. 3. The middle gneiss, of which the percentage proportion of silica is 69 or 70. The grey gneiss is generally the richest in mineral veins, so far as the Erzgebirge district is concerned. These divisions may be useful, but they are open to the objection that they are too sharply defined, and that it is impracticable to assign many unquestionably gneiss rocks to any one of them.

Granulite or Leptynite. In its mineral composition it closely resembles a gneiss containing a small proportion of mica, but in the more marked varieties the two rocks are readily distinguishable. The prevailing ingredients are always felspar and quartz, and nearly all the varieties contain more or less mica and garnet. Generally speaking, however, the latter two minerals are in inverse ratio to each, that is, the mica is comparatively abundant when garnet is scarce, while the garnet is most abundant in those varieties which contain the smallest proportion of mica. The felspar is chiefly orthoclase, which, however, is generally accompanied by oligoclase. The felspar forms a finely granular base, through which the quartz is distributed in flattened grains, lenticular particles and thin laminæ. Sometimes the laminæ are distributed in planes so as to give the rock an apparently fissile structure. This, however, is of rare occurrence, and generally the quartz is far less conspicuous in granulite than in gneiss or granite. The felspar is usually white, but is sometimes tinged with various shades of grey, yellow, and red; as it is by far the most abundant ingredient in the rock, the colour of the granulite is for the most part nearly the same as that of the felspar. The quartz is generally opaque and white, rarely grey and semitranslucent, and never dark. The mica is the white variety, rarely the dark. As it is always arranged in parallel layers the dark mica appears in dark seams, thereby giving a banded appearance to the rock. The garnets are red, and vary in size from poppy or millet seed to extreme minuteness. After the mica and garnet, the most important accessory ingredients are kyanite, which appears as blue grains in the more highly laminated granulites; tourmaline, or schorl, which is especially abundant in the granulite of Krumman in Bohemia, where it is called *Schorlaceous Granulite;* and hornblende, which is met with in the granulite of Czizek in Austria; at Glocknitzer, Schlossberg, and one or two other places, giving rise to what is called *spotted granulite.* At one time it was supposed that the *black granulite* owed its colour to hornblende, but this is now generally attributed to protoxide of iron. This rock blends into gneiss by means of its more highly micaceous and foliated varieties; and into granite and halleflinta by those which contain the smallest proportion of mica.

Granite. The general description of this rock is given under GRANITE, E. C. S. In this place the varieties only will be noticed. *Granite* in its most restricted sense includes such specimens as have the constituent parts of about the same average size. *Granitite* embraces those which contain a large proportion of oligoclase associated with a red orthoclase, quartz, and a little blackish green magnesia mica. It is readily distinguished from common granite by the larger display of oligoclase, its contrast with the orthoclase, which last frequently occurs in large crystals, thereby giving the rock a porphyritie aspect, and by the entire absence of white mica. This rock forms the great mass of the Riesengebirge; of the Brocken in the Hartz; and is also met with near Meblis and Ilmenau, at Baveno, on the shores of the Lago Maggiore, in Normandy, Brittany, and other districts. It includes the rock near Lyons called *miarolite* by Fournet. *Pegmatite* is a coarse-grained mass, chiefly consisting of orthoclase, quartz, and white mica, and usually occurring as irregular veins in the midst of other rocks of the granitic group. The quartz and orthoclase crystals are often several inches in length, and occasionally even a foot, while the mica also is sometimes developed in large plates. Tourmaline is usually present as an accessory ingredient, while green talc and iron pyrites are somewhat less frequent. Examples of it are to be found at Penig, Kursdorf, and Muhlau in Saxony; at Lurioga, Chanteloupe, and elsewhere, in France; at Finbo in Sweden, where the orthoclase, quartz, and mica attain unusually large dimensions, and the common beryl, topaz, garnet, gadolinite, orthite, are especially abundant; at Ytterby; at Mursinak in the Ural Mountains; and at Connecticut, Massachusetts, U.S. In *Porphyritic granite* the orthoclase, and sometimes the quartz, forms large crystals, and at Carlsbad, Ochsenkopf, and elsewhere. The *rappakivi* of Finland is a kind of porphyritic granite. It is composed of a granular matrix of felspar, black mica, and grey quartz, through which is scattered large rounded lumps of red felspar, which are frequently enclosed in a coating of greenish grey oligoclase. *Graphic granite* is another porphyritic variety, which, like pegmatite, usually occurs in veins or dykes, seldom or never in large masses. The orthoclase forms large crystals in the granular matrix; and is so arranged relatively to the quartz, that when the rock is fractured in certain directions, the cleavage faces of the quartz have some resemblance to Hebrew characters. *Protogine* is a crystallo-granular aggregation of red or white vitreous orthoclase, greenish-white, dull oligoclase, a grey or reddish quartz, a dark green, richly ferruginous mica, and a clear green talc-like mineral. The orthoclase is always the principal ingredient, and frequently forms crystals a few inches long; the oligoclase crystals are always less than half an inch in length, and generally only just visible; the mica forms small but thick hexagonal plates; and the talc-like mineral, which is least developed in the most granite-like specimens, is sometimes so distributed through the oligoclase as to give it a green tinge. It is extensively developed in the Western Alps. *Schorlaceous granite* or *Luxullianite* is a granite containing tourmaline in place of some of the mica. In *Graphitic granite*, graphite, and in *ferruginous granite*, micaceous iron enters as a substitute for the same ingredient. In *Adularia granite*, the ordinary felspar is replaced by adularia. The *Rumburg Granite* is a variety containing a blue quartz. Granite passes over into various other rocks. Thus by the richer development and parallel arrangement of the mica it merges into gneiss; by the occurrence of hornblende in small quantities it becomes a hornblende granite, and by the preponderance of hornblende to the exclusion of quartz and mica, it passes into syenite. By the replacement of quartz by elœite, it passes into miascite; by the disappearance of the felspar it merges into greisen; and by the disappearance of the mica it passes into felspar porphyry.

Syenite.—It is a crystallo-granular compound of orthoclase and hornblende usually containing small quantities of oligoclase, quartz, and mica. The orthoclase is the principal ingredient, and is generally of a red colour. It is rarely developed as crystals, but when these do occur they are either tubular and in twins, or columnar, and with their axes parallel. This last arrangement induces a greater or less amount of fissility in the rock. Generally, however, syenite presents no traces of any definite mode of arrangement of its parts, and is more or less granite-like in appearance. The hornblende is dark greenish, or nearly black, which, with the red of the orthoclase, gives a dark or brownish red tint to the rock. The quartz and mica are generally most abundant in those specimens which occur in the neighbourhood of granite. The syenite near Upsala is remarkable for its bluish grey quartz, which appears as a constant and equally distributed ingredient. Amongst its other accessory ingredients titanite, magnetite, iron pyrites, elœolite, and zircon, are the most important. Titanite is the most frequent; it occurs in small widely-scattered crystals; sometimes they are only to be detected by means of a lens by their brown or yellow colour, their adamantine lustre, and peculiar form. Zircon occurs in but few syenites as an important accessory ingredient, and some of these contain such large quantities as to be called *Zircon syenites*. The syenites of Laurvig and Brevig are examples. Angular fragments and concretionary masses of other rocks are not unfrequent in syenite. It is often associated with great fields of granite, and passes into granite by an intermediate variety called syenitic granite. There are also intermediate varieties which connect it with hornblende schist, diorite, and felspar porphyry. Cotta associates zircon syenite with miascite rather than with syenite proper. *Kersanton* and *Kersantite* are names for two closely allied rocks. The former is composed of a granular matrix of oligoclase and mica of a greenish or grayish colour, in which the mica sometimes occurs in pinchbeck brown or black short hexagonal columns or plates. Carbonate of lime often occurs in veins or concretions, and occasionally quartz. It is abundant in the neighbourhood of Brest and Quimper. Most of the finest ecclesiastical buildings erected in the middle ages in Bretagne are chiefly formed of this stone. The Kersantite occurs at Visemback and St. Maine, in the Vosges mountains. Like the last, it is a granular mixture of oligoclase and mica, but it differs by the presence of hornblende and the larger proportion of quartz as accessory ingredients. The oligoclase is white, the mica is brown, and the hornblende dark green. Iron pyrites, marcasite, and garnet also occur in small quantities. It is sometimes fissile, and sometimes porphyritic in its structure.

Miascite.—It is a granular mixture of white orthoclase, greyish or yellowish-white nepheline, and black mica. Its structure is generally granitic and coarse-grained; but some of the varieties, such as that at Miask, are fissile. Zirkon, sodalite, cancrinite, monazite, davyne, pyrochlore, apatite, hornblende, and quartz, are amongst its accessory ingredients. It is more nearly allied to syenite, especially the zircon-syenite of Norway, than to granite.

(Naumann, *Lehrbuch der Geognosie*, vol. i. 1858; Laurence's translation of Cotta's *Rocks Classified and Described*, 1866.)

GRAPHITE, or native carbon, has hitherto been found in the older rocks only. It forms beds and patches in the calcareous and siliceous rocks of the Laurentian series of North America; it also occurs in gneiss near Passau, at Stourbridge, Massachusetts, and elsewhere; in quartz near Travancore, Ceylon, and Moreton Bay, in Australia; and in the coal measures of North Greenland, New Brunswick, and probably of Ayrshire. Many other localities might be mentioned, but the more important are the Isle of Mull, Scotland, Grampound in Cornwall, the Alibert Mines of East Siberia, and Nijnei Tunkuski on the river Yenesei. The principal sources of the black lead for pencils, crucibles, &c., are Greenland, Siberia, and Griesbach, near Passau, from which last-mentioned place it is largely imported into this country.

Graphite, like the other forms of native carbon, is in all probability produced from the gradual decomposition of moist organic matter. It is only under these circumstances that carbon appears to have any deoxidating power at the ordinary atmospheric temperature. At high temperature, such as a red heat, it will separate oxygen from almost all its combinations, and hence its use in iron smelting, in which process part of the coal is expended in obtaining the temperature at which the other portion of the coal can deprive the iron ore of its oxygen, so as to reduce it to its metallic state. Hence, when we find graphite in deposits of magnetic iron ore, in crystalline rocks containing silicates, in granular limestones accompanying minerals partly composed of silicates of iron, such as hornblende, augite, it may be inferred that such rocks have never been subjected to any high degree of heat, and that both the graphite and the metamorphic changes in the rocks have resulted from chemical and physical actions at a moderate temperature.

(Bischof, *Chemical and Physical Geology*; Watts, *Dictionary of Chemistry*, art. *Carbon*.)

GRAPTOLITES. Our knowledge respecting this interesting group of fossils has been considerably increased of late years, especially by the discoveries of the Canadian Geological Survey in the Lower Silurian rocks of Eastern Canada. They were first noticed by Bromel, in 1727, in some of the Swedish slates, and described by him as blades of grass. In 1767 Linnæus grouped the forms known to him under the generic name *Graptolithus*. In 1821 Wahlenberg suggested that they were slender *Orthoceratites*, and consequently cephalopodous in their nature. Some years after, Nilsson stated that they belonged to the *Hydrozoa*. These three views have had many supporters, but, so far as we are aware, no one now supposes they are plants, and but few believe that they are cephalopods. This latter view was for a long time advocated by Messrs. Quenstedt and Geinitz, but has been recently abandoned by them. Consequently, the hydrozoan hypothesis is the only old one that finds any support now. In 1857 McCrady pointed out the analogy between the graptolites and the larvæ of the *Echinodermata*, but few persons appear to have maintained that the relationship between the two is anything more than analogy. The graptolites present a great variety of form, and are distributed amongst several genera. The simplest form may be described as being V-shaped; in some cases the two arms of the letter may be bent back so as to be almost horizontal, while in others they may present any degree of openness between this and almost complete verticality. The two arms are called ***stipes***, and the point from which they diverge, which is always more or less produced, is termed the *radicle* or *initial point*. Along the upper surface of the stipes are arranged a number of cellules, each of which is supposed to have been the residence of a soft-bodied animal, having a structure resembling that of the common *Hydra*. [See HYDROZOA, E. C. S.] On this supposition each tenant of a cell is called a *polypite*, a term described in the article just referred to. These cells are for the most part separated from one another, but their lower ends open into a canal, which it is thought was once filled with animal matter, and resembled the *cœnosarc* of the hydrozoa. In a second group there are four stipes, two of which diverge upwards, while the other two diverge downwards; and in some instances the bases of these stipes are connected by a disk or cup. From this we pass to species with eight stipes, with the stipes bifurcated and branched, and with the stipes arranged in a sort of network pattern. In nearly all these the form of the cellules is much the same; they occur on one side of the stipe only, and they are in close contact for a greater or less distance above the base. Hence these species are described as being *monoprionidian*, to distinguish them from such as have cellules on both sides of the stipe, or are *diprionidian*. There is no absolute demarcation between the two divisions, as species are known which connect them. Thus in the simple two-stiped monoprionidians the cellules are on the upper surface of the stipe. There is a two-stiped species, *G. divaricatus*, in which the cellules are on the under or lower side, and of a peculiar form. In *G. ramosus* the stipes are Y-shaped, and the cellules are arranged along both sides of the lower stipe, and along the outer side only of the upper stipes. And in *G. pristis* there is a simple lower stipe, with cells on either side. In some more complex forms of this division there are four ranges of cellules arranged at about right angles to each other. In addition to these there are a number of forms which are associated with the graptolites, but their plan of structure is quite different, having some resemblance to a *Sertularia* in the case of the genus *Ptilograptus*, and to a long feather in the case of *Buthograptus*. Another interesting form has been recently described by Mr. Nicholson, under the generic name *Corynoides*. The fossils referred to this genus were found in the Lower Silurian anthracitic shales, near Moffat, and are considered to be the polyparies of a *Coryne*-like zooid. Each polypary is supposed to be independent, and the polypite to be a free-swimming organism. The polypary is a long trumpet-shaped tube, with the free edge divided into several unequal teeth. In the same shales were found specimens which appeared to consist of two of these tube-like polyparies arranged on opposite sides of a central axis or stipe.

Little is known as to the development and mode of reproduction of these beings. Professor Hall and others have noticed what appear to be sacs attached to the stipes and projecting beyond the cellules. These, it is suggested, may be reproductive sacs, such as are commonly found in the sertularians. Close to the sacs, numerous bodies have been discovered, believed to be germs just escaped. The smallest of these consist of little more than an initial point or radicle; a diverging process of similar character on either side; a longitudinal axis; and a sac-like covering or test, which has scarcely assumed the form of cellules. It is connected by larger forms with the mature graptolite. The evidence known to us as yet is exceedingly scanty, and caution is required in drawing any conclusions; but, supposing it is established that the graptolites are *Hydrozoa*, the fact of the young being similar in form to the adult is remarkable, since probably all the modern forms undergo a marked metamorphosis prior to reaching the mature form.

The following synopsis of genera is that proposed by Professor Hall:—

I.

Species consisting of stipes, or fronds, with a bilateral arrangement of the parts; a solid axis, with a common canal extending along each series of cellules.

	1. The successive buds developed in tubular cellules which are usually in contact for a greater or less proportion of their length, and inclined towards the axis.
Graptolithus . . Linnæus.	*a.* Cellules in single series along one side of a common solid axis. Stipes two or more, from a common origin with or without a central disk. Sub-genera, *Monoprion, Didymograptus, Monograptus, Tetragraptus*, etc. *b.* Cellules on one side of slender branches which are developed on one or two sides of a long slender axis or rachis, the free extremities of which are likewise celluliferous. Ex. *G. gracilis; G. divergens.* *c.* Cellules developed in parallel arrangement on two sides of a common solid axis. Stipes narrow, elongated. Sub-genus *Diprion*=*Diplograptus.*
Phyllograptus . . Hall.	*d.* Cellules developed in a cruciform arrangement on the four sides of a common or coalescent axis. Stipes elliptical or subelliptical.
Climacograptus. Hall.	2. Cell apertures excavated in the margin of the stipes without tubular or cup-form extension; the cell apertures upon one or both sides of the stipe. Ex. *C. bicornis*, etc.
	3. Solid axis eccentric or subexterior, with cellules developed in parallel ranges on opposite sides of the stipe and in contact throughout their entire length.
Retiolites . . Barrande.	*a.* Known only as separate stipes with reticulate test.
Retiograptus . . Hall.	*b.* Occurring as simple stipes and as compound fronds; test smooth.

II.

Species having a common trunk or stem, or growing in sessile groups of stipes from a common origin, without distinct bilateral arrangement of parts. Cellules in single series on one side of the stipes or branches, and arranged along a common canal or axis.

Dendrograptus Hall.	1. Branches free (*i. e.*, not connected by transverse bars), cellules in contact or closely arranged.
Callograptus . Hall.	2. Branches unfrequently and irregularly connected by transverse processes.
Dictyonema . . Hall.	3. Stipes and branches more or less regularly united in a reticulate frond without elongate stem.
Inocaulis . . Hall.	4. Stipes round or flattened, growing in groups and bifurcating above; margins denticulate; surface rough or scaly.

III.

Slender cylindrical branches with tubular cellules arranged in single (or in double ?) series. Cellules not in contact in any part of their length. . . . . **Rastrites**, Barrande.

IV.

Species having a common axis or rachis, with slender lateral alternating branchlets. Cellules unknown.

Thamnograptus, Hall.

V.

Species having a common axis, more or less frequently bifurcating, with pinnulæ closely and alternately arranged on the opposite sides; cell apertures on one face of the pinnulæ.

Ptilograptus, Hall.

VI.

A simple flexuous rachis, with slender flexuous flattened pinnulæ, arranged in alternating order at close and regular intervals on the two sides. Cell apertures unknown or circular.

Buthograptus, Hall.

VII.

Strong stems, which are numerously branched. Branches and branchlets slender, arranged in cohorts. Cellules undetermined.

Oldhamia (?), Forbes.

The graptolites are an extinct family. Their range geographically is known to have extended throughout North America, Europe, and Australia, and geologically to have been almost entirely confined to the Silurian epoch. They would appear to have chiefly frequented the extensive mud-flats of the Silurian seas, not far from the land; and hence they are usually found in shales. Barrande's study of the distribution of the group led him to the conclusion that the graptolites attained their maximum development at an earlier geological period in North America and Western Europe, than in the south-eastern parts of Europe. In America the family first appears in the Potsdam sandstone which forms the uppermost part of the Cambrian series; but has its greatest development in the rocks of the Quebec group, forming part of the lower Silurian series. Few representatives of the family have been found in the Trenton limestone, the rock which succeeds the Quebec group, but it is again largely represented in the Hudson River series, which abound in shales. The formations above this in North America chiefly consist of limestones, which contain a species here and there up to the top of the Silurian series. It is probable that when shales of corresponding age to the Trenton and the various middle Silurian limestones are discovered, the geological development of the family will be more fully indicated.

The graptolites have not as yet been found in England in the strata believed to correspond in age to the Potsdam sandstone, viz., the Lingula flags, although, being shaly, they would seem to be likely localities for them if they existed. The first appearance of the family in England is in the lower Silurian rocks, and their maximum development in the Llandeilo flags, and their Cumberland representatives, the Skiddaw slates; which strata appear to be somewhat higher in the geological series than the Quebec group. They occur in less abundance in the Wenlock Shales, and in the Ludlow formation, but appear to have died out before the commencement of the Devonian series.

In Bohemia and Saxony the family is comparatively rare in the lower Silurian, and attains its greatest development in the rocks named "étage E" by Barrande, which appear to correspond with the lower Llandovery, forming part of the middle Silurian of England. In these countries, as in those already referred to, the Graptolites do not ascend into Devonian rocks.

GROMIDÆ. [Foraminifera, E. C. S.]

GYMNOGASTER, a genus of dipterous insects, belonging to the same great family to which the common horse-fly belongs, viz., *Muscidæ*. It is founded by Lioy on the *Anthomyia dissecta* of Meigen. His definition of the genus is that the epistoma is quadrate in form, and prominent; the abdomen is not villose nor bristly beneath, while in the male the penultimate segment bears two appendages on its lower side; and the second transverse vein of the wings is perpendicular and straight.

END OF PART I.

NATURAL HISTORY.

SUPPLEMENT: PART II.

The abbreviations E.C. and E.C.S. signify the English Cyclopædia and the English Cyclopædia Supplement.

H

HADROSAURUS. A genus of extinct Dinosaurian reptiles, whose remains have been found in the newer cretaceous strata of the United States. It appears to have been the American representative of the gigantic *Iguanodon* of Europe, resembling it in its enormous dimensions, herbivorous habits, and anatomical structure. The only species as yet established is the *H. Foulkii*, Leidy, numerous bones appertaining to which have been dug out of a dark-coloured, tough, micaceous clay, abounding in marine fossils, near Haddonfield, New Jersey.

Although in many points of its structure it approached nearer to the crocodiles than to any other group of living reptiles, yet on the whole it seems to have been built upon a more highly organised model, so as to adapt it for filling an analogous place in nature to the rhinoceros or hippopotamus, since, like those mammals, it would seem to have been a huge, bulky, river-frequenting, masticating herbivore. No reptiles of the present day have such functions; but in the cretaceous period, when huge pachydermatous mammalia were probably unknown, such functions were performed chiefly by reptiles. More than this; they even acted as carnivores in the place of *Felidæ*. The circumstance that *Hadrosaurus* and its contemporary allies performed what the *Pachydermata* and *Felidæ* now do is an argument, in addition to the absence of any remains of these mammalia in the cretaceous strata, that they did not exist then. If, further, we consider that the pachyderms and felines are apparently better adapted for their special functions than the pre-existing reptiles, we have, it may be, one clue why reptiles should have been so huge and so predominant in the secondary era, and why they should have lessened in importance when the mammals stepped in and occupied their places.

There are several features in the skeleton of *Hadrosaurus* which indicate its high degree of organisation as compared with living reptiles generally, which features are, however, met with in other genera which flourished with it. The vertebræ present some. In fishes the centrum or body is usually cupped or concave at both ends, but in one genus, *Lepidosteus*, the anterior concavity is filled up by ossification, and converted into a convexity, thus forming a ball and socket joint. In embryonic reptiles, and in nearly all the mature forms now existing, the development of the vertebra does not extend beyond the stage at which it is cupped at both ends; but in several genera either the front or the back concavity is converted into a ball. The *Batrachia* in their ichthyomorphic condition, or as tadpoles, have biconcave centra, but when they acquire their mature condition as terrestrial quadrupeds the vertebræ have the ball in front in some genera, as in *Pipa*, and behind in others, as in most frogs and toads. In the *Ichthyopterygia*, an extinct order of exclusively marine habits, the vertebræ were biconcave. In the *Sauropterygia*, also an extinct order of aquatic reptiles, the vertebræ were usually but slightly biconcave, and occasionally flat at one or either end. In the *Ophidia* the vertebræ are procœlian—that is, they are united by ball and socket joints, in which the socket or concavity is at the fore end of the centrum; the socket has its upper border somewhat more prominent than its lower, so that it has a slightly downward aspect. Snakes progress mainly on land by the aid of their ribs and scales. The *Lacertia*, or lizard order, also have procœlian vertebræ, but the balls are not so prominent, nor so forwardly directed as in the snakes. In some exceptional groups, such as the Geckos, the vertebræ are biconcave. The lizards are partly aquatic, partly arboreal, and partly terrestrial, in their mode of progression. In the recent *Crocodilia* the axis vertebra is flat in front, and convex behind; the two sacral vertebræ are flat at one end and concave at the other; the first caudal is biconvex, and all the other vertebræ are concave in front and convex behind. Crocodiles are partly aquatic, and partly terrestrial in their habits. In most of the secondary *Crocodilia* the vertebræ had flat or slightly concave faces, while a few had some of their vertebræ with the ball in front and the hollow behind. In *Hadrosaurus* the cervical were convex in front and concave behind, or opisthocœlian in structure. The anterior dorsals are also concavo-convex, but not to so great an extent as the cervicals, while a still slighter degree of convexity and concavity occur in the middle dorsals, and the hindmost dorsals possess a feeble opisthocœlian structure. All the caudal vertebræ have biconcave centra. In so far, then, as *Hadrosaurus* departs from reptiles generally, it approaches the herbivorous mammals, amongst which it is usual to find a highly developed opisthocœlian joint structure in the vertebræ of the neck, which shades off in the anterior dorsals. As examples we would quote the rhinoceros, the tapir, the horse, and the camel. This structure seems to be related to a facility of bending the neck for the purpose of browsing.

Another illustration is afforded by the union of the neural arch to the centrum—a union which is so perfect in *Hadrosaurus* that scarcely the trace of a suture can be detected. This condition is very rare amongst fishes, is generally met with only in those reptiles that are terrestrial, and is almost universal in mammalia. The sides of the centra have an articular surface, to which was attached the head of a bifurcated rib, the other surface being on the neural arch; as we pass backward, the roughened concavity becomes a process, especially on some of the dorsals; and the two surfaces are arranged nearly in the same way as indicated under CROCODILIA, E. C. S. col. 319. The caudal vertebræ indicate that the tail was laterally compressed—a form which enabled the *Hadrosaurus* to make its way through the water.

The teeth have the same conformation and peculiarity of structure as in the *Iguanodon*, but were far more closely packed together, thereby adding to their efficiency as masticators. They were implanted by their fangs in sockets, and their enamel crowns were situated obliquely, those of the lower jaw being directed outwardly, and those of the upper inwardly. In wearing down, the carina of the crown and the lateral edges of enamel stand up as ridges, and these, with the depressed adjacent softer portions, rendered the tooth an excellent triturator. Leidy believes the teeth were grouped in a quincuncial manner; but we cannot make this point clear without cuts, and therefore we refer the reader to Leidy's under-cited work for fuller explanations.

If the vertebræ of *Hadrosaurus* reveal habits quite exceptional from those of recent reptilian life, their limbs present us with indications of others quite as unexpected to those who have confined their attention to living forms. The hind limbs were of extraordinary size and strength, and far exceeded the fore limbs. Thus a femur of an adult specimen was found to be 41½ inches long, and the tibia 36¾ inches, the two together being 6 feet 6 inches when placed end to end. The humerus was 22½ inches, and the ulna 23¼ inches, the two together being barely 3 feet 10 inches. This disproportion of the limb occurs in several other cretaceous reptiles, and from this fact, together with the nature of the bones, one is led to conjecture that the monstrous *Hadrosaurus*, *Iguanodon*, &c., leaped about on their hind legs, like the kangaroos of the present day. The disproportion of limb would not be incompatible with a quadrupedal mode of progression, as illustrated by frogs; but the footprints left by *Iguanodon* demonstrate that the members of that genus habitually walked or jumped on their hind legs, and hence it may be surmised that other Dinosaurians allied to them progressed in the same fashion. And this brings to mind the curious analogy that while kangaroos form part of a fauna in which this superior development of the hind limb is a prevalent feature, so it would seem that in the time of *Hadrosaurus* the same peculiarity prevailed amongst its terrestrial allies, and may be was a modification of structure characteristic of the fauna of a particular region. What a strange world it must have been where great *Hadrosauri* 25 feet in length jumped about in herds, pursued by equally gigantic carnivorous reptiles, such as *Lœlaps*, clearing upwards of 30 feet at each bound.

(Leidy, J., *Cretaceous Reptiles of the United States*; Cope, E. D., *Fossil Reptiles of New Jersey, American Naturalist*, vol. i. p. 23.)

HALCROSIA. [Crocodilia, E. C. S. cols. 322; 324.]

HATTERIA. Until recently this was the generic name applied to a lizard which forms one of the most characteristic species of the reptilian fauna of New Zealand. It is now usually called *Sphenodon*, under which head further notes respecting it are given [Sphenodon, E. C. S.]. In an earlier article [Geographical Distribution of Animals, E. C. S. col. 429] we unfortunately said it was the nearest living representative of *Telerpeton*, whereas we intended to say *Hyperodapedon*, a genus which is found in the same rocks and locality as the last mentioned. [Hyperodapedon, E. C. S.]

HAYTORITE is a pseudomorph of chalcedony after datholite.

HÖRNESITE, a name applied by Haidinger to a hydrated arsenate of magnesia found in the collection of minerals in the Museum at Vienna, and believed to have been obtained from some locality in the Bannat. Only one specimen is known. In it may be detected flat rhomboidal laminæ with angles of 36° and 144°, which cleave readily parallel to their broad faces, which have a pearly lustre. The crystals probably belong to the monoclinic system. The colour is snowy white, but thin flakes are transparent and flexible. The hardness is 1, or somewhat less, and the specific gravity 2·474. The analysis by Hauer yielded the following result:—

Arsenic acid	46·33
Magnesia	24·54
Water	29·07
Loss	·06

This answers to the formula, $3\,MgO, As_2O_5 + 8\,H_2O$. The mineral readily fuses before the blowpipe, and will even melt, in thin splinters, in the flame of a candle. It is insoluble in water, but soluble in acids. The specimen in the Vienna Museum is embedded in a coarsely granular calcspar, and is associated with garnets.

HORNBLENDE [E. C. vol. i. col. 70; Augite, E. C. vol. i. cols. 343, 344; Hornblende, E. C. vol. iii. col. 129]. Under the term *Actinolite* are included the glassy and fibrous hornblendes. There are three varieties of actinolite, viz., the *glassy*, the *fibrous*, and the *granular*. The glassy includes the bright green crystals having a vitreous lustre. When the crystals are closely packed together in wedges or radii they belong to the *fibrous* variety, and when aggregated in an irregular manner they are sometimes called *asbestiform actinolite*. *Raphilite* is an example of this last variety; it is found near Lanark in Canada, and at Croey Head, in Donegal, Ireland. The theoretical chemical composition of actinolite is given in the article Augite, E. C., under Strahlstein. The following is an analysis by Rammelsberg:—

Silica	56·77
Magnesia	21·48
Lime	13·56
Protoxide of iron	5·88
Alumina	0·97
Loss by ignition	2·20
	100·86

In some varieties there are also protoxide of manganese and fluoric acid, the latter existing probably as a double fluoride of silicon and calcium. The green is attributed to small quantities of iron and chromium. The specific gravity is usually about 3·05. Actinolite has been found in several of the Cornish mines; near the Bowder Stone, Cumberland; one or two places in Wales; many parts of the North of Scotland; while abroad it occurs in the Zillerthal (Tyrol), Norway, Sweden, Greenland, Finland, Piedmont, and Pennsylvania.

HYDRA [E. C. vol. iii. cols. 150—152]. But little requires to be said about this genus in addition to the long account already given in the E. C. Our knowledge respecting this group is still imperfect, more especially in connection with the structure of the reproductive organs and the development of the embryo; and we are still in ignorance as to the way in which contraction and extension are effected. No muscular fibres have been detected, as stated by Corda.

This genus of about half a dozen species is believed to be entirely confined to fresh water, while all its nearest allies in structure (with the exception of *Cordylophora*) are exclusively marine. Of the seven or eight species known, four are generally distributed in Europe. Leuckart states that one or two species exist in the North Sea, and Bosc that two species live on the sea-weed in the Atlantic Ocean. These latter observations require further confirmation, for, if true, they prove that the fresh-water hydras do not occupy so remarkably isolated a position, geographically, as is usually supposed.

Hydra is, perhaps, the simplest of all the *Hydrozoa*, and is regarded by most naturalists as the typical form. [Actinozoa, E. C. S.; Hydrozoa, E. C. S.] It is the only genus in the order *Hydridæ*.

HYDROZOA, a class of animals, concerning which various details have been given in the Cyclopædia under the articles Acalephæ, Hydra, Hydroidæ, and Lucernariadæ. It comprises in round numbers about 500 or 600 species, which present so great a diversity of form that it is at first sight difficult to perceive any structural character common to the group. As the perception of this relationship of plan often greatly facilitates the understanding of the real structure of any particular species which may be the object of curiosity, we will endeavour to indicate in what this relationship consists, and why it is that the genera *Hydra*, *Coryne*, *Sertularia*, *Pelagia*, *Diphyes*, and *Lucernaria* are associated together in the same class. And, perhaps, the best way to develope this relationship will be to give an account of (1) the development of the ovum and embryo, (2) the typical forms of each group, (3) the principal modifications of each of the typical forms, (4) the phenomena relating to generation, or the production of eggs, and (5) the classification of the genera and families.

The structure of the ovum is so uniformly identical in all animals that the description of the ovum of any one animal will apply to that of every other; and although the eggs of but few *Hydrozoa* have been properly observed, there is much reason to believe that the structure of the unknown eggs is essentially the same as that of *Laomedea flexuosa*, which has been so carefully described by Professor Allman, whose account will be somewhat closely followed. The ovum (*fig.* 1) is about ·01 inch in diameter just before segmentation commences. It is of a granular structure, and contains a distinct germinal vesicle about ·002 inch in diameter, situated very excentrically, and easily separated from the surrounding fluid or vitellus (yolk). When isolated on the stage of the microscope it is seen to be of a beautifully spherical form, and to be filled with a transparent colourless fluid, in which floats, sometimes one spherical body or the germinal spot, and sometimes a group of from 2 to 10 such

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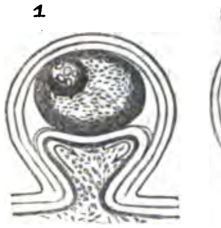

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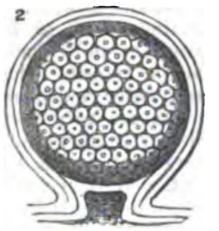

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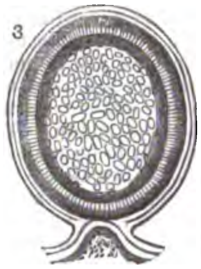

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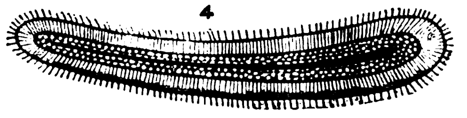

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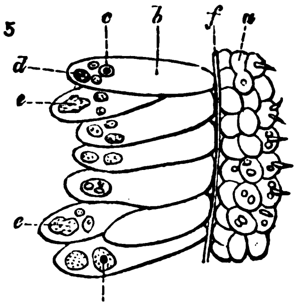

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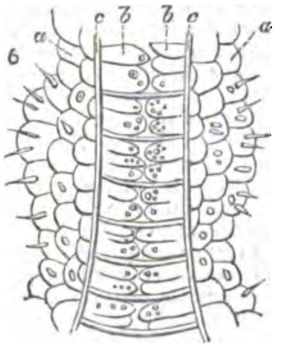


bodies, which probably represent the germinal spot. These bodies are soluble in sea-water, and the walls of the vesicle permit the passage of water through them, so that they should be placed in some fluid in which they are not dissolved. Such a fluid is that forming the vitellus, as also sea-water to which a little tincture of iodine has been added. The latter is the more preferable, since it renders them and their contents more distinct, and shows them to be themselves vesicles containing a few minute granules. The vitellus (yolk) is composed of minute spherical corpuscles of apparently homogeneous structure, and of granules so small as not to admit of measurement. The ovum, which is enveloped in a thin vitelline membrane, gradually increases in size, and after a time the germinal vesicle disappears, but no change in the structure of the egg seems to follow as a consequent result. What becomes of it is unknown, but Professor Allman thinks it probable that it bursts and scatters its contents, which mingle with the vitellus or yolk. However, whether this is so or not, segmentation sets in almost immediately after the disappearance of the germinal vesicle. The yolk splits into two halves, each half divides, and the subdivision continues. These products of successive duplication are called cleavage spheres. When there are about 36 such cleavage spheres a distinct nucleus appears in some of them, and when they are still more numerous, every sphere is seen to have its own nucleus (*fig.* 2). It is probable that the invisibility of the nuclei in the earlier formed and larger spheres is due to their being thickly imbedded in the thick opaque vitellus. The cleavage spheres consist, like the original yolk, of spherical corpuscles intermingled with still smaller granules. At this stage a new phenomenon presents itself. The spheres forming the outer layer of the ovum become transformed from spherical bodies into long prismatic ones, having their main axis perpendicular to the surface of the egg, and form an outer wall (*fig.* 3). Up to this point the main feature has been the conversion of an apparently homogeneous substance into a heterogeneous one, a feature which the ovum of *Laomedea* shows in common with the ovum of man and the higher animals. This will be evident on comparing the account above given with the passage concerning the human ovum, quoted in the article REPRODUCTION IN PLANTS AND ANIMALS, E. C., vol. iv. col. 568. The analogy between them is not merely one of form: it extends to the general functions of the two layers. In the higher animals the inner layer undergoes but little change or differentiation, and throughout the whole life of the individual it plays a pre-eminently important share in the function of alimentation; on the other hand, the outer layer undergoes great changes, and gives rise to the most complicated structures, such as the integuments, bones, muscles, nerves, and sensory apparatus. The various organs are produced by budding from one or both these layers. The same thing occurs in the *Laomedea* and all the *Hydrozoa*. The outer layer is developed into the hard tegumentary tissues, the bands of muscles, and the various organs of sense. The inner layer undergoes little change, and is principally employed in aiding digestion. The organs are developed from one or other, or both of the layers. With this digression, we will return to consider what are the further changes undergone by the ovum of *Laomedea*. The nuclei which were previously visible in the cleavage spheres have now ceased to be distinguishable, while these spheres at the same time show a distinct investing membrane. On breaking down the ovum under the microscope, it is found to consist of loosely aggregated cells, some spherical, some elongated, and all with a more or less numerous brood of smaller cells within them. The outer layer is now well marked, the ovum begins to change from a sphere into an elongated shape, and the large cells with their endogenous brood, have become a multitude of small free vesicles mingled with the granules, which have all along formed a part of the constituents of the ovum. This elongated body gradually shows signs of contractility, and it breaks through the *gonophore* or embryo-sac which envelopes it, and, straightening itself, appears as a long conical body (*fig.* 4), or embryo. It is entirely clothed with vibratile cilia, by means of which it moves slowly along the bottom of the vessel containing it. It still consists of two layers, which have been termed the endoderm, and the ectoderm; but in addition we have a central cavity, which appears to have been formed by the liquefaction of the innermost cells and granules, and which represents the digestive cavity of the future adult animal. As yet there is no aperture leading into it; but the ectoderm contains a multitude of minute oval bodies having a high refractive power, which it is supposed may be the rudiments of the thread cells. This stage is generally known by the name *planula*.

The development of the ovum into the planula has been carefully traced in a few species only of the *Hydrozoa*, but the development of the planula into the adult hydroid form has been traced in many. The changes undergone by *Eudendrium racemosum* form a good illustration of what occurs in most cases. The planula or ciliated embryo roams about for two or three days, then loses its cilia, and with them its activity, although it still creeps slowly from one place to another by the general contractility of its body. When it reaches a suitable place it contracts into a flat disk-like shape, throws out a secretion from the lower or *proximal* surface, and attaches itself thereby to some fixed object. From this flattened disk a slight cylindrical and hollowed column arises. The base now expands laterally, while at the same time it becomes depressed vertically, so as to acquire the condition of a little circular disk of adhesion. At the same time also the embryo becomes enlarged a little beneath its free or *distal* extremity by the formation of a slightly prominent circular ridge, while an exceedingly delicate periderm has been excreted as an almost imperceptible film over its whole surface. The next change is the division of the disk into lobes, separated from one another by radiating fissures, which commence as shallow notches at the circumference, and thence gradually increase in depth until they nearly reach the central vertical column. These lobes, like the columns, are composed of two layers, and each contains a prolongation of the general cavity of the body. The lobes increase in number by successive dichotomous division. While this is proceeding, the embryo itself grows larger, the circular ridge becomes more pronounced, and a portion of the front part of the ridge is more decidedly marked off from the rest of the body. The periderm at this part is more distinctly seen than elsewhere in consequence of its partial withdrawal from the included structures. Soon after the ridge developes into a circle of about 10 short thick tentacles while at some distance behind them the body is narrowed into a short nearly cylindrical stem springing distinctly from the centre of the basal disk, and the more contracted part which lies in front of the circle of rudimental tentacles is plainly recognisable as the proboscis of the future polypite. The tentacles increase rapidly in number by the development of fresh ones between those already formed. The second set appear to spring from the same line as the first, but may be distinguished by the tentacles forming it being shorter than the others. The tentacles consist of two layers, the outer or ectoderm, and the inner or endoderm, whose structure presents no greater complexity than is met with in the planula stage. The ectoderm is apparently formed of a single layer of prismatic cells, while the endoderm seems to fill the entire axis with a mass of minute spherical loosely aggregated cells. Just behind the tentacles the body of the young polypite is seen to be excavated by a large cavity, in which is a multitude of loose spherical cells filled with a red granular pigment thrown off from the inner surface of the walls. The polypite is still invested in the delicate chitinous periderm, which entirely covers it, even to the very ends of the tentacles. For some time it has formed a loose covering over the free end of the body, and it ultimately ruptures in front of the tentacles, and thereby admits the free access of water to the surface of the polypite. The tentacles also have greater freedom of expansion; the proboscis is perforated, and this perforation is the first indication of the communication between the digestive cavity of the polypite and the medium in which it dwells. We purposely avoid using the word mouth for this perforation, and stomach for the general cavity of the body, because we hold that the same word should only be applied to homologous parts, that is, to parts which occupy corresponding positions in the same plan of structure. The so-called mouth we shall term *actinostome* or *polype-mouth.* The young *Eudendrium* is now a true polypite. Its stem elongates; while the body, tentacles, and proboscis rapidly acquire all the characters of the adult. It developes a creeping *stolon,* as also new polypites, and undergoes various other changes; but these phenomena will be considered in another part of this article.

The changes which we have somewhat minutely described are, in most of the essential points, in all probability identical with those which occur in nearly all *Hydrozoa.* They have been verified in the genera *Cordylophora, Clava, Cyanœa,* and *Aurelia.* The observations on the last were made by Agassiz, and, as his description supplies some details not noticed in the ova of *Laomedea,* we will repeat it here. The species to which the eggs belonged was *A. flavidula.* He saw in the ovary a number of simple globular bodies which he concludes were eggs, since, beginning with them, a graduated series of similar bodies was found to merge into other bodies which had all the characteristics of genuine eggs. The smallest of these bodies, when examined by a high magnifying power, appeared like homogeneous masses of jelly. When a rather larger body is examined with the same magnifying power it resembles a sac containing a few large globules, which globules are perfectly clear and homogeneous. These globules are regarded by Professor Agassiz as representing the yolk, and he draws attention to the fact that very few of them are required to fill the egg. In a slightly larger egg the globules are much smaller and more numerous, and hence it is supposed the original globules have been broken down into smaller ones. Apparently there is no definite boundary to the egg, but changes like these would seem to indicate that there is one, although invisible. In an egg somewhat larger than the last a vesicle is developed which ultimately fills one half the diameter of the egg. This is the germinal vesicle, and within it may be seen a still smaller one which is the germinal spot; both vesicles are clear and homogeneous. The yolk globules are now so small and closely packed that they look like mere granules; and the colour of the yolk has changed from its former transparent colourless appearance to a bluish-grey colour. For a short time after this the increase of the egg in size appears to be more due to the growth of the inner vesicles than to the yolk. The phenomena which appear at this time are so important that we will give the original account, premising that the Purkinjean and Wagnerian vesicles correspond to our germinal vesicle and germinal spot. "The Purkinjean vesicle bursts, and yet the space occupied by it remains clear, and the Wagnerian vesicle remains intact, and might be mistaken for the Purkingean vesicle were it not for its peculiar appearance, by which it may be recognized when compared with other Wagnerian vesicles of undoubted character and relations. The yolk cells at this period are larger than ever, and have an apparent diameter, under this magnifying power, of about $\frac{1}{30}$th of an inch, or in reality $\frac{1}{3000}$th of an inch. The vitelline sac is very thick, a peculiarity also noticeable in another genus, *Cyanœa,* but never in the eggs of any of the naked-eyed Medusæ. Finally the Wagnerian vesicle bursts and leaves a homogeneous clear space in the centre of the egg. To what degree this clear space is filled up, or whether it disappears altogether during segmentation, we are not able to state, for we have not seen the segmentation of the yolk in *Aurelia* or in *Cyanœa.* After segmentation the vibratile cilia appear, and by their means the young leave the ovary, and make their way into pouches in a long curtain appendage which hangs from the lower side of the disk of the mother *Aurelia.* Sometimes the young are of a globular shape and sometimes oval when they leave the ovary, and there is also a great variation in size, but this is probably mainly in consequence of the great degree of contractility and expansibility possessed by them. In this early stage, even when the individual possesses a globular form, the motion is rolling and zigzag; but when the individuals are elongated they proceed in an almost direct line with one end forward. This direct motion is most favourable to effecting a passage from the ovary to the pouches, and in most cases the individuals are of this elongated shape when they make the transit. The young at this stage have distinct inner and outer walls, and a digestive cavity, but no mouth. The cilia are very short, and their motions appear to be more or less voluntary; for it frequently happens that when all the cilia are bent in one direction they suddenly stop, pause for a moment, and then resume activity with their points turned in the opposite direction. After a time the peripheric portion just beneath the cilia, and the centre, become slightly transparent, the transparency increases until the outer part forms a distinct layer enveloping the whole, and the central part forms a cavity bounded by a distinct outline; and the embryo is now clearly divided into (1) the ectoderm, (2) the endoderm, and (3) the digestive cavity. The digestive cavity enlarges, the uniform transparent gray colour changes into a faint rosy tint. The mouth is now formed by the depression of the outer surface of the inner wall, by the conversion of this depression into a perforation or channel, and by the subsequent perforation of the outer wall. The next phase is the assumption in succession of an ovate, of a pyriform, and of a long cylindrical shape; the conversion of the upper part of the body from a cylindrical to a somewhat quadrangular form; and the projection of the four angles. The embryo is now from $\frac{1}{120}$th to $\frac{1}{88}$th of an inch in length. The final changes we have to notice here are the deepening of the rosy tint into a brownish-pink colour, the settling of the embryo on the narrower end of its body, and its attachment to a solid surface by means of a horny secretion."

In a few genera, as for example *Tubularia* and *Myriothela,* a different order of things prevails. According to Prof. Allman the granular plasma (*p, fig.* 22) which occupies the position in *Tubularia* corresponding to that occupied by the ovary of other *Hydrozoa,* gives rise to fragments which develope into embryos. But as they never show any traces of a germinal vesicle or germinal spot, some persons have contended that they cannot be regarded as true ova. In reply to these Professor Allman urges that since "the plasma in which they originate holds in the gonophore which contains it a position precisely similar to that held by the undoubted spermatogenous tissue in the male gonophores of the same species, and as nothing else is presented by the hydroid which can in any way be regarded as ova, we should, by denying to them the essential attributes of ova, be reduced to the anomalous alternative of admitting the existence of the male element without the correlative female one." According to Dr. Wright the embryos of *Chrysaora hyoscella* are developed from similar bodies which never show any traces of a germinal vesicle or spot: this species we may mention is said to produce planuloid embryos. In *Tubularia* the generative product lies between the ectoderm and the endoderm, but appears to be connected with the latter rather than the former, since it appears to grow in bulk by the absorption of this membrane. The changes which the detached masses of plasma undergo are thus described by Professor Allman. In the act of development the detached mass becomes extended as a disk over the residual plasma. In this disk we can always recognize a differentiation between its peripheral and central portions. Next, from the circumference of the disk short and thick processes radiate all round, and these soon elongate themselves into tentacles, the disk at the same time gradually becomes more gibbous on the side turned away from the axis of the gonophore; its interior becomes hollowed out into a digestive cavity, and a mouth makes its appearance in the centre of the opposite side, or that in contact with the plasma. The embryo now retreats from the plasma, the mouth is seen to be elevated on a conical prominence, while the side opposite to the mouth becomes more and more prolonged until it assumes the form of an elongated oval peduncle into which the general cavity is continued. The extremity of this prolongation presents the appearance of delicate striæ (probably fibres) radiating for a short distance from its central point—a peculiar structure which might easily lead to the belief that an aperture was here present. At the same time a circle of very short tentacula makes its appearance immediately around the mouth. In this state it escapes from the gonophore, and, after continuing free for a period, the side opposite to the mouth becomes ultimately developed into a cylindrical stem, which soon clothes itself with a periderm, and fixes the young *Tubularia* to some neighbouring object.

In this mode of development the chief distinctive peculiarities are that the embryo does not acquire the ciliated locomotive stage, but passes the period corresponding to it in other *Hydrozoa* in connection with its mother; and that it does not become free until after the appearance of the mouth (actinostome) and tentacles. In this free condition the embryo is called an *Actinula*. It will be seen that this actinula-stage corresponds, as far as development is concerned, to the stage shown by the other *Hydrozoa* a short time after they have fixed themselves. The development of the fresh-water hydra has never been traced, but certain facts render it probable that it may assume the hydroid form without passing through the planula-stage. It has been stated that in some genera the ova are directly developed by a continuous series of developmental phases into the adult medusæ; but the evidence on this point has not yet, so far as we know, been satisfactorily established in any single instance. In one species of *Lizzia*, however, Claparede has traced the development of the egg into a medusoid form without any intermediate hydroid stage; and although but slight changes were apparently required to convert this into the adult form, still the gap was sufficient to prevent our assuming that it might be filled up by direct metamorphism.

From the foregoing paragraphs it appears probable that with the exclusion of a few doubtful cases, which may or may not prove to be exceptions, the ova of all *Hydrozoa* assume, sooner or later, a form which agrees in all general points of structure and relative position of parts with the common fresh-water *Hydra*, which is by common consent viewed as the representative form of the class, chiefly because it has the simplest organisation. A tolerably accurate idea of its form may be gained from the article Hydra in the Cyclopædia, but there is room for a few extra details here. On examining a *Hydra* we find that it consists of a conical column attached by the narrow end (*hydrorhiza* or *adherent disk*), and of a number of tentacles which spring from the margin of the broad end, and surround a short, conical projection, whose narrow end points forward, and terminates in an aperture or polype-mouth. The column or stem is hollow, and consists of two parts; viz. (1), the part in front of the tentacles (post-buccal cavity of Allman), and (2), that just behind the tentacles, where the food is digested (the stomach of Allman, and the polypite of Huxley). The *polypites* are usually single, but when two or more polypites are connected together the compound group is called a *hydrosoma*.

In the adult *Hydra* the stem is a triple-walled sac, each wall having a special name, and probably a special function. The outer wall is known as the *ectoderm;* the middle wall as the *basement* or *supporting membrane* and *muscular layer*, and the inner wall as the *endoderm*. The ectoderm is transparent, and without any apparent structure in the common *Hydra* (*H. vulgaris*), although when the creature is contracted it is full of wrinkles and folds which have a resemblance to the outlines of the cells in the endoderm. It has imbedded in it the lasso cells, of which there are two kinds, of different sizes; the smaller and most numerous have a simple thread which, being protruded for a short distance, gives a bristly look to some of the clumps of lasso cells; the larger ones are pear-shaped when their thread is ejected, and have at the base of the thread three slightly curved spines. In *H. viridis* the ectoderm is cellular, not homogeneous. Beneath the ectoderm is the *muscular layer*, which appears as a sharp, well-defined line, separating the outer from the inner wall, and presents no trace of structure under a magnifying power of 200 diameters. Beneath this is the *endoderm*, which lines the general cavity of the body, and which has a decided cellular structure. The cells are closely applied against one another, and vary in shape from short prisms to long cylinders, according as the *Hydra* is contracted or expanded; their long axis is at right angles to the axis of the stem, and when viewed endways they appear like an irregular network. The inner ends of these cells are ciliated and form the lining to the general cavity of the body, which is filled with a fluid containing a number of nucleated cells. On the inner surface of the endoderm there are a number of brownish granules, which according to Reichert are situated within the endodermic cells, and do not compose a distinct layer by themselves.

Such appears to be the structure of *Hydra;* but the authorities differ greatly in the functions they attribute to the different parts. The remarkable contractile power of the *Hydra* is well known, a power which seems to be exceedingly well developed in the group of *Hydrozoa*. Dr. Johnston, whose opinion was adopted in the Cyclopædia article, attributed this power to certain muscles and to the propelling effect of a current of water. This opinion is now worthless; for what were considered to be muscles by Corda are now known to have been the external margin of the tentacular knobs, and of the cells contained in them, while there is no evidence to show that any current of water is created by propulsion; and if there were this would imply a muscular system or something analogous to it. The expansion of the tentacles, however, is quite independent of any such agency, for they expand and contract when separated from the body of the *Hydra*. Reichert asserts that the ectoderm is the seat of the contractile power; that it is homologous with the sarcode of the amœba, sponge, and other Protozoans; and that the middle wall is formed from it by an excreting process. The author gives his reasons for adopting these conclusions, but they do not appear to us by any means sufficient ones. According to other authorities, the contractile power is lodged in the endoderm layer; thus Leydig assigns it to the transparent fluid contained in the cells of the endoderm, and others attribute it to the cell membrane. Until recently this last opinion appeared to be the most prevalent; but latterly it has been generally thought that this power resides in the middle layer; and the main argument in favour of this view is, that in the higher *Hydrozoa* an undoubted muscular system occupies a corresponding position.

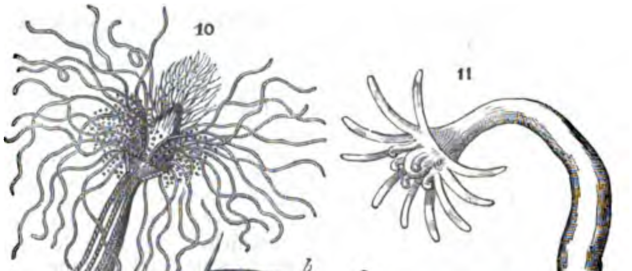
Cordylophora is another freshwater genus, whose structure is very similar to, but somewhat more complicated than, that of *Hydra*. In this genus a number of polypites are grouped in a dendritic form by a common stem or cœnosarc. The stem of each polypite is long and cylindrical, and the tentacles are short and clavate. The cavity of the stem is divisible into three parts, viz., (1) the post-buccal cavity, which is situated between the mouth and the plane from whence the tentacles have their origin; in shape it varies from a tube to a globe, according as the projection supporting the mouth is or is not dilated; and the cells lining it present a smooth surface. (2) The digestive cavity, which occupies all the interior of the expanded portion of the club-shaped stem, situated behind the origin of the tentacles; the cells which line it are large, and their inner ends are uneven and separated, so as to give them the appearance of villi projecting into the digestive cavity. And (3) the canal of the cœnosarc, which is continuous with the digestive cavity, but the connection can be temporarily closed by the approximation of the walls of the lower part of the digestive cavity; the cells lining this canal are small and present a smooth surface. The tentacles are hollow, and are in direct communication with the digestive cavity.

The body-wall of *Cordylophora* is composed of the same three layers as in *Hydra*, but in the stem they are enveloped by a fourth, known as the polypary. At present only one species belonging to this genus is known, and consequently some of the details given below respecting the structure of the various layers may be characteristic of the species rather than of the genus. The *ectoderm* is a well defined membrane, and is composed of cells, in which feature it resembles *Hydra viridis*, and differs from *H. vulgaris*. Many of these cells, more especially those forming the outer row, have developed within them other and smaller cells, which contain the thread-cells. These thread-cells are ovate capsules, slightly curved and tapering at one end, and filled with a transparent fluid. A minute cylinder is attached to the inner side of the sharper end, which extends along the axis of the cell for about two-thirds of its length. When the animal is irritated this cylinder is everted through the end of the capsule, and when extended it forms a conical projection terminating in a long filament. At the point where the filament is attached to the apex are three minute curved spheres. The thread-cells are developed in all parts of the ectoderm, but they are far less numerous where this layer is covered by the hard polypary (and where, consequently, they cannot be used as organs of offence) than in the tentacles. In the latter place they are developed in large numbers and collected into groups which form conspicuous knobs or swellings; but they are most numerous at the extremities of the tentacles. The ectoderm rests upon the muscular layer, which in this species is not structureless as in *Hydra*, but, according to Allman, contains a number of longitudinal fibres, which may be seen in the portion of the cœnosarc not enveloped in a polypary, in the polypite, and throughout the whole length of the tentacles. The *endoderm* forms the inner wall, and is composed of long cells having their length arranged at right angles to the main axis of the

stem. Their size and character vary according to their position, the greatest development being in the digestive cavity. Here they form a remarkable tissue, with their rounded ends prominently projecting, as shown in *fig.* 5, where *a* is the ectoderm, *f* the muscular layer, and *b* the endoderm. Towards the inner half of these cells are several free secondary cells, many of which themselves contain several smaller cells or nuclei. In some of the secondary cells (*c*) there is a single nucleus floating in a transparent fluid; in others (*d*) the nucleus can hardly be seen in consequence of the presence of a number of brown granules; and in others the interior is filled with a brood of young cells. There are also particles of brown granular matter, which appear to have been liberated from some of the secondary cells. This glandular-like structure resembles that found in the corresponding part of *Hydra,* and probably indicates a similar function in both. Dr. Allman states that the secondary cells are obviously secreting cells destined by the rupture of themselves and of their mother-cells to discharge their contents into the stomach; while the granular masses are considered to be the result of this secreting action. In the tentacles the endoderm (*b*, *fig.* 6) is composed of smaller cells, which, however, nearly fill up the tentacular cavity, and at times do so entirely by the approximation of the opposite surfaces; they contain within them other cells of the same glandular appearance as those in the endoderm of the stomach. *Fig.* 6 represents the structure of a portion of a tentacle, *a* being the ectoderm, and *c* the muscular layer; in it will be noticed a series of what appear to be septa. Dr. Allman thinks the appearance is due, not to actual partition, but to the occurrence of regular intervals in the continuity of the endodermic layer. A similar appearance is met with in *Hydra,* in which genus, Reichert asserts, they are actual septa, and that the communication between the chambers is by means of circular apertures in the septa. In *Coryne,* again, there is a similar appearance, but, as we shall see further on, a third mode of accounting for it is proposed. We do not know that any one has recorded the existence of cilia on the endoderm of *Cordylophora,* but it is probable they have much to do with the tremulous motion seen by Dr. Allman in the corpuscles of the fluid contained in the cavity of the cœnosarc. He notices that this fluid has an irregular motion, and that the motion of each corpuscle is frequently confined to a circuit not greater than the diameter of the cavity. Sometimes a group of corpuscles rush forward, and then suddenly stop, allowing others to pass by them, while sometimes no traversing motion can be detected either in the fluid or the corpuscles. When the corpuscles are moving in their inner path they also have a second kind of motion of a peculiar vibratile or tremulous character, and this same motion may also be observed when they are otherwise stationary. This motion we apprehend is caused by cilia, but Dr. Allman says it "may be due to the currents produced by the active vital processes going on in the secreting cells of the endoderm, which can hardly take place without causing local changes in the chemical constitution of the fluids in immediate contact with the cells, and a consequent disturbance of the stability of these fluids."

We have now to notice the *polypary,* of which no traces are found in *Hydra.* It invests the branches, stems, and creeping stolons of the dendritically formed group, terminating at the place where the polypites commence. In the young branches it is thin and almost colourless, but in the old branches it is yellowish brown, and composed of several layers. In the young branches the endoderm and polypary are in close contact, and the same remark will probably apply to the old branches. In the latter, however, there is apparently a wide interval between the two for considerable lengths, and the only connection seems to be by a series of processes extending from the ectoderm to the polypary. The places where these processes exist are frequently marked by external annular corrugations, such as occur near the bases of the branches where they spring from the cœnosarc. According to Dr. Allman, it is highly probable that a thin delicate membrane is in contact with the inner surface of the polypary, and that the lacunæ are in the ectoderm itself. His principal reason for this opinion is that the spaces are unquestionably lacunæ in the ectoderm in the nearly allied genus of *Syncoryne.* The polypary is a structureless substance, which is believed to be a mere secretion from the ectoderm. Its interior diameter increases with the age of the zooid, but how the enlargement is effected is not known, although Dr. Allman says it must be by distension.

The next genus whose structure we propose to notice is *Coryne,* which is marine, like all the other Hydrozoan genera, with the exception of the two already treated of. We have selected *C. mirabilis* as a good example of the genus, partly because it is better known than most other species in consequence of the careful, minute, and beautifully illustrated description which Professor Agassiz has given of it. The zooids form irregularly branched colonies, in which the cœnosarc is attached to some solid object for a short portion of its length, the rest stretching freely into the water. The same parts are found in *Coryne* as in *Cordylophora;* thus there is the common trunk, or cœnosarc, from which is developed a number of stems or branches, which terminate in a swollen part containing the digestive and post buccal cavities; while from the swollen part arise one or more circles of tentacles. The substance of the body wall is composed of four layers in some parts and three in others, which correspond to those termed polypary, ectoderm, muscular layer, and endoderm in *Cordylophora.* Professor Agassiz, however, alludes to two walls only, which appear to be the endoderm and ectoderm. This arises from his regarding the polypary as an excretion product, and from his not recognising the existence of the muscular layer. The ectoderm and endoderm form a double tube, extending throughout the whole community, from its base to the tip of the tentacles, but their relative thickness vary considerably in different parts. Thus, in the young polypites, or heads, as Agassiz terms them, and in the main part and base of the stems of zooids of all ages, the two walls have about the same thickness; but in old polypites the outer wall is the thickest in the middle part, diminishing in thickness by one half towards the tip, and at the tip again expanding to form nearly the whole of the spherical expansion at that point. The inner wall of the tentacles is a continuation of that in the digestive cavity, and far exceeds the outer wall in thickness. The digestive (or, as Professor Agassiz calls it, chymiferous) fluid circulates within the endoderm, but by what means he does not know, since he states that no cilia have been detected. At times there is an exclusive circulation in the digestive cavity limited to the space above the neck, where on such occasions the opposite surfaces of the endoderm approximate towards each other so as to shut off the communication with the lower chymiferous channel; the channel corresponds to the cavity of the cœnosarc in *Cordylophora.* This circulation occurs when the polypite is distended to its utmost, as if to expose the largest possible extent of surface to the influence of the digestive fluid. The endoderm of the digestive cavity is lined with brownish red granules, which granules are frequently torn off, and borne along in the current, with a quivering movement. The fluid does not penetrate into the tentacles, which in *C. mirabilis* are said to be solid. The tentacles have a great power of contraction and extension, their extent varying from twice their own diameter to the length of the polypite. The *polypary, c, fig.* 7, is a horny sheath, composed of irregular concentric layers, and is structure-

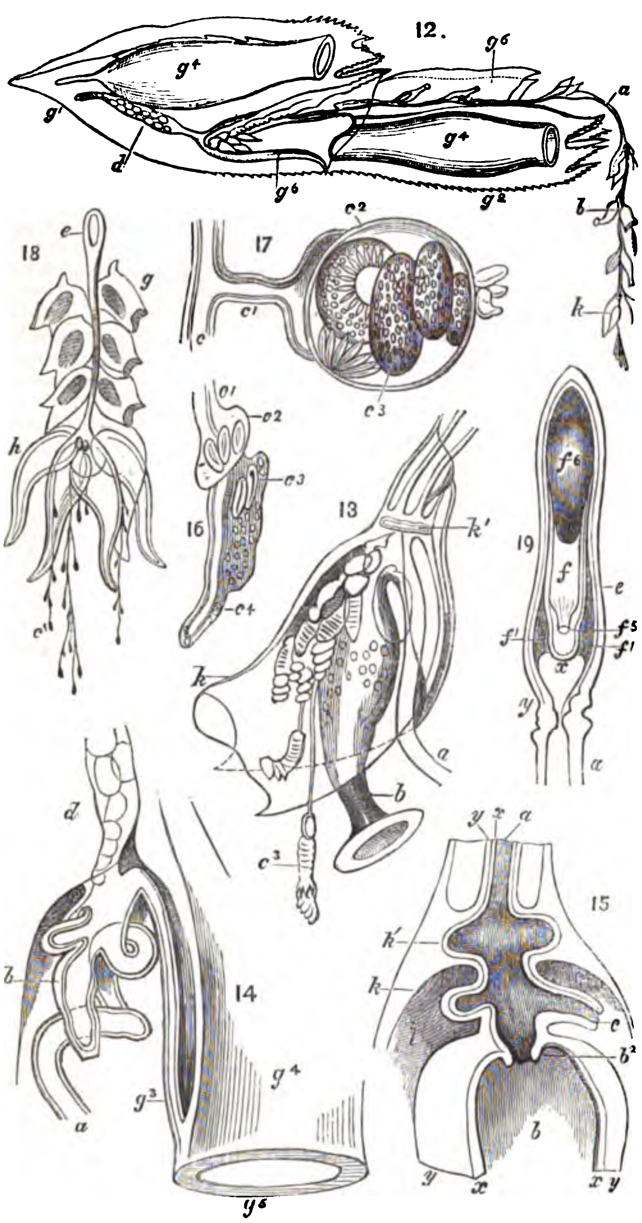


less, although the boundaries of the layers give it an apparent fibrous structure. It envelopes the ectoderm, which in the adult shows no signs of cellular structure with an ordinary magnifying power, if the thread cells imbedded in it are excepted; it frequently appears to be longitudinally, but superficially striated, especially in the polypite, where the striæ are double, and like muscular fibres. This apparent striation, Professor Agassiz states, is due to furrows, caused by the longitudinal wrinkling of the walls. In the young polypite, the endoderm is decidedly cellular, as shown at *b*, *fig.* 8. The cells are quite as broad as those of the endoderm, but much shorter; while their length is coincident with the thickness of the ectoderm itself. Their inner faces are flat, and their outer ends are rounded, and each contains a homogeneous colourless fluid, in which is an exceedingly transparent nucleus. The form of these cells varies; when the zooid is extended, they are hemispherical, but when it is contracted they are short prisms. Professor Agassiz does not notice the *muscular layer;* but Professor James Clarke has satisfactorily determined its existence; the latter states that it is a layer of longitudinally fibrillated muscular bands, situated between the endoderm and ectoderm, precisely similar to what is found in *Tubularia.* The *endoderm* is composed of large cells, whose shapes vary according to their position. Their shape low down in the stem can hardly be distinguished in consequence of the great development of brown cells; but higher up, at the neck, they are distinctly visible as curiously curved prismatic wedge-shaped cells, having their narrower ends innermost, and occupying the whole thickness of the wall (*d*, *fig.* 8). Their outer and broader ends are more or less rounded, so as to leave a number of interspaces. In the polypite these cells are much larger, have straight parallel sides, and are wedge-shaped laterally; this last characteristic is a common feature in cells arranged in a convergent series round a central axis. When seen endwise they have an irregularly polygonal shape, and overlap one another. They are filled with a transparent fluid, which appears to contain no granules or nuclei, as in the previously noticed genera. But the bodies noticed in *Hydra* and *Cordylophora* are probably represented by the reddish cells which form a distinct lining to the digestive cavity (*dd*, *fig.* 8). They are of an irregular form, and provided with several tail-like processes, which project between the cells of the endoderm; each contains a dark nucleus, which seems to be the origin of the colour of this lining. The tentacles are composed of the ectoderm, *c*, muscular layer, *d*, and endoderm, *a*, (*fig.* 9). The cells of the last are said to occupy the whole of the centre, and to present the appearance of transverse partitions, *e*, when viewed with a low magnifying power; but a higher power shows they are arranged in two rows, one opposite the other, and that the thick irregular column which appears in the middle of the tentacle when viewed laterally, is the double wall of the contiguous cells. The nuclei, *g*, seen in these cells are coarse granules, imbedded in the double walls at their line of junction. No mention is made of cilia on the inner surface of the endoderm; but according to Professor Huxley it is lined with cilia on most, if not all, *Corynidæ* and *Sertulariadæ.* The globose head is shown at *f.*

So far, then, as the internal structure and external form are concerned, there is an evident relationship between the *Hydridæ* and *Corynidæ;* although amongst the former there is but little, and amongst the latter a great variety in form. The principal difference is the development of the cœnosarc and polypary in the *Corynidæ;* and it is mainly upon the modifications in the cœnosarc and tentacles that the various generic characters are based. Thus, in *Tubularia* the cœnosarc consists of long tubes intertwined together; in *Eudendrium* it forms tree-like masses, with thickly crowded branches; in *Hydractinia* it forms a rough layer on the surfaces of shells. The tentacles are variously arranged, as will be seen from the following summary given in Greene's admirable little Manual of the Cœlenterata. In *Tubularia* and *Corymorpha* (*fig.* 10) a fringe of short appendages immediately surrounds the mouth of the polypite, from the base of which, close to the distal extremity of the cœnosarc, arises a second circlet of much longer filiform tentacula, fewer in number than those of the upper row. *Vorticlava* (*fig.* 11) also possesses a twofold series of tentacles; but here, those of the lower circlet are twice as numerous as those of the upper, which are five in number; short, stout, and capitate. In *Clava, Cordylophora,* and *Coryne,* the tentacles appear irregularly scattered along the sides of each polypite, though most abundant towards its distal [or free] extremity. In *Coryne* the mouth is highly flexible, possessing the power of bending towards the tentacle which has seized the prey, and of converting itself upon occasion into a kind of sucking disk. The polypites of the allied genus *Stauridium* are distinguished by the possession of two or more cycles of dissimilar tentacles, separated from one another by a considerable interval, each cycle including four tentacles; the lower row filiform, the upper whorl, or whorls, capitate, and placed at right angles to one another and the polypite. (The writer has observed, in a colony of *Stauridium,* a group of the polypites, which differed from the ordinary polypites in having an upper cycle of eight tentacles, without any lower cycle of four filiform tentacles. The aquarium in which they grew does not contain more than a quart of water; it has had nothing put into it for three years, and the colony has been constantly watched. The appearance of this variety was coincident with a rapid increase in the number of the colony, which took place in the first few warm days in the early part of spring of 1867.) In *Pennaria* there is a basal circlet like that of *Tubularia,* between which and the mouth of the polypite lie scattered numbers of shorter tentacles, resembling those of *Vorticlava.* In *Myriothela* multitudes of wart-like tentacles crowd the whole surface of the club-shaped, solitary, polypite. Similar to these are the tentacles of *Acaulis,* which exhibits, in addition, a basal series of long prehensile appendages. These, however, disappear as the organism approaches maturity, so that this form may possibly be but a young condition of *Myriothela.* A single series of rather long tentacles inserted as in the freshwater *Hydra* arises at a short distance below the mouth in *Trichydra, Clavatella, Perigonimus, Bimeria,* and *Eudendrium.* Some species of these genera seem to foreshadow an arrangement of the tentacles, which in *Hydractinia* becomes sufficiently conspicuous. Around the mouths of the digestive zooids in this genus two rows of alternating tentacles are placed so close to each other that they appear, at first sight, to constitute a single series; the lower tentacles, which are the shorter, projecting at right angles to the body of the polypite, from the axis of which the upper tentacles very slightly diverge. These, however, have no connection with the long tentacular appendages arising directly from the cœnosarc. Lastly, in *Lar,* each polypite supports but two tentacles, above which the mouth is furnished with a pair of wide projecting lobes, capable of being approximated closely to each other, and serving, doubtless, as efficient organs of prehension.

In the *Sertularidæ* the polypites resemble those of the *Corynidæ,* their principal difference in structure being a higher development of the polypary, which in this group is thicker, more conspicuous, and more durable. The cups which contain the polypites are prolongations of the polypary, and are technically known as *hydrothecæ.* The order *Sertularidæ* is sometimes made to consist of two families, viz., the *Sertulariadæ,* in which the polypites are sessile, and the *Campanulariadæ,* in which they are supported on a stalk. In the majority of cases the stalk is ringed. Many authors consider the *Graptolitidæ* to be nearly allied to these two families, and they have brought forward a great deal of evidence in favour of this view; but it appears to us that the facts are not quite convincing, that they are not sufficiently extensive, and that it is possible they may rather belong to the *Polyzoa.* In the present state of our knowledge we have preferred to describe them under a separate heading. [Graptolitidæ, E. C. S.]

In the next groups the Hydrozoan type of structure is so modified that great difficulty has been experienced in understanding what functions are performed by the various parts; and although Professor Huxley has thrown much light on the subject in his 'Monograph on the Oceanic Hydrozoa,' yet there are many obscure points which would be readily explained by a careful examination of the development of a few species belonging to different genera. As an illustration of the order *Calycophoridæ* (which is the name Huxley proposes to substitute for that of *Diphydæ,* used in the E. C. article), we will select *Diphyes dispar,* which is the same as *Diphyes Bory.* The generic characters of *Diphyes* are thus given in the E. C. vol. i. col. 44 :—"Body nucleiform, indistinct, situated in the bottom of a deep cavity, whence proceeds a long tubular production, furnished throughout its extent by proboscidiform suckers, having at their root granular corpuscles and a cirrhiferous filament. Natatory bodies nearly equal and similar; the anterior with two distinct cavities; the posterior with a single one, with a round aperture provided with teeth." Huxley's definition is :—"Both the nectocalyces have a mitrate form, with five more or less convex faces, and hence a pentagonal transverse section. The proximal nectocalyx is as large as, or larger than, the distal one. The hydrophyllia are folded round, like the spathe of an arum, and have their outer surfaces not facetted or irregular, but smoothly convex." It will be at once seen that the two definitions differ widely, both in the technical terms employed, and in the characters upon which the generic distinction is based. In the first we have such familiar terms as bodies, cavities, tubular production, suckers, granular corpuscles, filaments, natatory bodies, and teeth; and in the second a number of unfamiliar expressions. What we wish to show in describing *Dyphyes dispar* is that it possesses parts strictly similar to those of the *Corynidæ* and other *Hydrozoa*, combined with some which are not found in the groups we have already noticed. *Diphyes* differs from *Hydra*, *Coryne*, and the *Sertularidæ* in the hydrosoma, or mass of zooids, being free and locomotive, and never attached to stones, &c., and accompanying this difference of habit is a far greater development of the apparatus by which locomotion is effected. In *D. dispar* there are two bodies having somewhat the shape of a mitre, g^1, g^2 *fig.* 12 (*nectocalyx*), each of which contains a cavity, g^4 (*nectosac*); both of these nectocalices, or *swimming-cups*, as we shall in future call them, are endowed with considerable powers of contraction and dilatation. In the walls of both the swimming-cups is a cavity g^6 (*hydrœcium*) containing a long filiform body, *a* (cœnosarc), which supports at intervals groups of appendages. Each group consists of the parts shown on an enlarged scale in *fig.* 13; viz., the polypite, *b*; tentacles spinging from the base of the polypite, c^3; and of a sort of hood or cover, *k*, called the *hydrophyllium*, which is analogous to, but not homologous with, the hydrothecæ in the *Sertularidæ*. These are the prominent features belonging to *D. dispar*, in common with all the species belonging to the same order; and the main difference between this and the orders already illustrated by typical forms are that in *Corynidæ* and *Sertularidæ* the cœnosarc is fixed to a stone, and has a more or less ramified form; but in the *Calycophoridæ* the cœnosarc is attached to a swimming-bell of extraordinary size relatively to the polypites, and is not branched. The attached end of the cœnosarc in all these cases serves as the means for placing the animals in corresponding positions, so as to obtain uniformity of description. It is always called the *proximal* end, whatever may be its actual position. Thus in the *Hydra* it corresponds to what is frequently termed the lower end; in *Diphyes* to the end which is foremost in swimming; and in the *Medusidæ* it corresponds to the upper side. The opposite end, which is nearly always that which is growing, is termed *distal*. It is important to bear these distinctions in mind, for otherwise it is impossible to define the precise position of the various parts.



The cœnosarc has much the same structure as in the *Corynidæ*, consisting of an outer and inner layer, with an intervening muscular layer, composed of well developed longitudinal fibres. It is soft, has no *polypary*, and is remarkable for its contractility. In many cases it is so delicate and transparent as to be scarcely visible, although it may be several inches long, and may support fifty or more polypites. Its distal end differs but little from the cœnosarc of the *Corynidæ*, &c., but its proximal end is considerably modified. In the *Calycophoridæ* this end is somewhat dilated (*fig.* 14) to form a small chamber, which is ciliated on its internal surface, and from which ducts, one of which is shown at g^3, are given off connecting the somatic cavity with the system of canals developed in the walls of the swimming-cup. At its proximal end this chamber is constricted, and communicates by a narrow channel with a sac, *d*, termed by Huxley the *somatocyst*, the cavity of which is almost obliterated by the excessive vacuolation of the endoderm. The swimming-cups are developed at the proximal end of the cœnosarc; and, like the cœnosarc, are composed of endoderm, muscular layer, and ectoderm. At the sharper end of the cup is a cavity, from which four *nectocalycine* canals, g^3, proceed, which canals traverse the walls of the cup, and terminate in a circular canal surrounding the mouth of the cup. In the *Calycophoridæ* the swimming-cups are usually two in number. The *polypites* are similar to those already described; the mouth is at the distal extremity, and is frequently expanded into a disk-like form; the middle part is wider than the rest, its walls are much thicker, its endoderm is developed into slender conical villi, and it is especially the part where digestion is effected; and there is a basal or proximal portion. These appear to correspond to the three parts described by Dr. Allman in *Cordylophora*; but in the Calycophorids no tentacles are developed from the polypite. In *Diphyes* there is a structure which appears to correspond with a similar part in *Cordylophora*. It consists of a strong fold of the endoderm, b^2, *fig.* 15, whose lips project into the median or digestive cavity, and can be closed. Huxley calls it the *pyloric valve*, and states that the oily globules formed by the digestive process accumulate near the valve, and after having been kept rotating for a certain time, are discharged into the somatic cavity by the simultaneous contraction of the digestive chamber and dilatation of the valve. The tentacles spring from the peduncular part of the polypite, and vary much in structure. Professor Huxley gives the following account of them as they occur in the *Calycophoridæ* and *Physophoridæ*:—"The tentacles in the various genera of these orders gradually increase in complexity as we advance along a series the lowest term of which is *Velella*, and the highest *Physophora*. The tentacles of *Velella*, in fact, differ in no essential respect from those of the *Hydridæ* and *Sertularidæ*; they are simple cæcal processes of the wall of the cœnosarc, with a greatly vacuolated endoderm. Those of *Porpitæ* have the same fundamental structure, but they are branched at the ends. The tentacles of *Apolemia* are described by Leuckart and Gegenbaur as simple, tapering, unbranched filaments, which are beset with large thread cells on one side, and are traversed by a narrow ciliated canal. One of these tentacles is said to arise from the base of each polypite. The tentacles of *Physalia* exhibit an advance on this structure. They arise independently from the cœnosarc, and each is provided at its base with a large pyriform saccular dilatation, the *basal sac*. The tentacle itself is a filament, which in a large specimen attains the length of many feet when fully extended. It has no lateral branches, but it is beset along one side at regular intervals with reniform enlargements, full of large thread cells, which are disposed transversely to the axis of the tentacle, and look like so many beads threaded upon it. On the opposite side the tentacle widens out into a ribbon-like muscular band, which, attached above to one edge of the basal sac, is the agent of its rapid and extensive contractions. A canal traverses the whole length of the tentacle, and sends cæcal diverticula into the reniform enlargements, while above it communicates with the cavity of the basal sac. It has been supposed that the latter organ, by its contraction, drives the liquid which it contains into the canal of the tentacle, and thus effects its elongation. Without denying that such may be its office, I would remark that the tentacles of other species which are not provided with basal sacs are just as capable of rapid elongation. The reniform enlargements to which I have referred may be regarded as rudimentary lateral branches. If they be supposed to elongate and become filamentary, the result will be a tentacle very similar to that possessed by *Rhizophysa*, except that in this genus there is no basal sac nor muscular band, and that each tentacle is attached to a polypite. The lateral branches of the tentacles of *Rhyzophysa* have one wall much thicker than the other, but it contains only spheroidal thread-cells, and the branches are not divided into distinctly characterized regions. In *Forskalia*, however, while the tentacles have essentially the same structure, each lateral branch is divided into three distinct portions: a proximal slender part; a median division with one wall much thicker than the other, containing numerous elongated thread-cells, arranged in transverse rows perpendicularly to the wall, and flanked on each side by a longitudinal series of larger oval thread-cells; and, finally, a terminal cylindrical thread full of small rounded thread-cells. I shall term the first of these regions the *pedicle*, the second the *sacculus*, and the third the *filament*. The muscular band of *Physalia* is partially represented by two pairs of muscular cords, which, according to Leuckart, lie in the thin wall of the sacculus. In the contracted state the sacculus and the filaments are thrown into spiral coils. The structure of the tentacles of *Halistemma* is essentially the same, except that they are provided with a more complex muscular apparatus. The tentacula of the *Calycophoridæ* resemble those just described, and arise either from the base of the gastric division of the polypite, close to the pedicle, or from the latter itself. The larger oval thread-cells are confined to the distal end of the sacculus, which is usually bent so as to have a half-moon shape, the thick wall forming the convexity. The filament is coiled up into a close spire, folded against the straight thin wall; and where it joins the sacculus the points of five or six oval thread-cells commonly project like those of the rowel of a spur.” Where the peduncle joins the sacculus it exhibits a small dilatation, which Professor Huxley considers to be the rudiment of the *involucrum*. Leuckart describes a structure in the sacculus of the *Calycophoridæ* which he terms the *angel band*. According to him it is a simple, but strong and sharply-defined muscular cord, which is folded in zigzags, and lies in the posterior (thin) wall of the canal of the sacculus, partly covers it at the sides, and then appears to be coiled almost spirally around it. The proximal end passes gradually into the pedicle, while the distal extends as far as the beginning of the filament. In *Praya* and *Hippopodius* this cord has a diameter of about $\frac{1}{3000}$th of an inch, and differs in no essential respect from the muscles in other parts of the body, especially in the stem, although at times a slight transverse striation can be detected in it. In *Diphyes*, and still more in *Abyla*, however, this muscular cord gradually becomes thicker during its course, so as even to attain as much as $\frac{1}{400}$th of an inch in *Abyla*, and therewith assumes a very distinct transverse striation, so that, especially in *Abyla*, it might be compared to the most beautiful transversely striated muscular fibres. No nuclei can be observed in this cord, nor can its sheath be distinguished from its contents. It appears as if the transverse striation were caused by a regular jointing, for the edges of the cord are completely incurved at intervals, corresponding with the constrictions between the joints. In *Abyla*, furthermore, this muscular filament is but little flattened, and becomes triangular in many places by the mutual pressure of the super-imposed folds. If one of the thin edges be accidentally turned directly towards the microscope, the transverse striation readily leads one to suppose that two series of transverse rods are imbedded in the cord. Notwithstanding what Leuckart says, it is very doubtful if this is really a striated muscular band. In the tentacles of *Stephanomia*, which in many respects resemble those of *Halistemma*, a new part makes its appearance in the shape of a sort of hood, which is developed at the junction of the pedicle with the sacculus, and encloses the latter like a cup. Huxley terms this the *involucrum*. It is a solid lamellar process of the ectoderm, containing no internal cavity. The sacculus is very long and spirally coiled, terminates in a single filament, and has a well-developed muscular band in its thin wall. In the genera *Agalma* and *Athorybia* the involucrum has become much larger in proportion to the sacculus, and the latter is terminated, not by a single filament, but by two filaments, between which the sacculus ends in a clear, thin-walled median lobe devoid of thread-cells. Finally the tentacular branches attain their utmost complexity in *Physophora*, the spheroidal involucrum here completely investing the sacculus, which lies coiled up within it. In their younger state, however, they exactly resemble those of the tentacles of the *Calycophoridæ*, that is, they commence as simple cæcal, double-walled processes of the stem, which gradually elongate and develope into three well-defined portions. One of the walls of the median division is much thickened; and rows of elongated thread-cells disposed vertically to its plane are developed in it. The distal division remains short, and acquires small thread-cells only. The proximal division elongates into a slender pedicle devoid of thread-cells for the greater part of its length. Where it merges into the middle division it dilates, and contains large as well as small thread-cells. Similar thread-cells make their appearance in the proximal end of the median division. Thus far the development of the tentacles corresponds to those of *Diphyes*, and it is evident that the basal division, c^1 c^2 *fig*. 16, corresponds to the pedicle and involucrum, the middle division, c^3, to the sacculus, and the distal, c^4, to the filament. (*Fig*. 16.) On further developing the sacculus lengthens, and becomes coiled upon itself, while the involucrum dilates and acquires a quadrate outline. In a further stage the involucrum, c^2, *fig*. 17, has become immensely dilated so as to form a sort of hemispherical cup closed on all sides, except one small aperture through which protrudes the three lobes into which the extremity of the filament, c^3, is divided. This stage is shown in *fig*. 17.

The structure of this involucrum differs from that of the corresponding part in *Stephanomia* and *Agalma*, inasmuch as it is only partially formed by the lamellar expansion of the ectocyst; the greater part of its wall being constituted by a cup-shaped dilatation of the pedicle itself, from whose edges the proper involucrum rises. As a consequence of this enlargement of the pedicle the attached end of the sacculus, distinguishable at once by its large oval thread-cells, has been carried to the distal extremity of the involucrum instead of remaining at its proximal end. And at the same time as the sacculus has increased in length far beyond the diameter of the sac, it has become coiled into a helix with several turns. They are still far removed from their adult condition; more advanced stages have been described by Kölliker, but his description wants confirmation. In addition to the ordinary polypites there are some other bodies which closely resemble them when in an imperfectly developed state; these are termed *hydrocysts*, and are regarded by some as organs of prehension and touch; their structure and position seem to indicate that they may correspond to those modified zooids met with in other Hydrozoan groups which are specially related to the process of reproduction in the same way as the ordinary polypite are specially related to the process of digestion. The *hydrophyllium*, like the *hydrotheca* in the *Sertularidæ*, serves as a protection to the polypite; but, although similar in function, the two parts are essentially distinct. The *hydrotheca* is a cup-shaped body formed entirely from the polypary, or outer layer of the ectoderm; the *hydrophyllium* is composed of both ectoderm and endoderm, as shown in *fig*. 15, where *k′* is the endoderm, and *k* the ectoderm. The same figure shows how the hydrophyllium springs from the pedicle of the polypite. The hydrophyllium presents considerable variation in the different genera. In *Diphyes* it is a thin, smooth, transparent, glossy, arched plate, *k*, the edges of which overlap both above and below the point of attachment, *fig*. 13. In *Abyla* it is thick, of a cuboidal or pyramidal form, and its edges do not overlap. In *Praya* it is a reniform body, with four short cæcal processes. In *Vogtia*, *Hippopodius*, and probably *Sphæronectes*, it is absent.

We will now return to the definition of *Diphyes* with which we commenced the survey of the group to which that genus belongs. If expressed in the more recently established terms it would read thus: *somatocyst* nucleiform, indistinct, situated in the bottom of the *hydrœcium*, whence proceeds the *cœnosarc*, furnished throughout its extent with *polypites* having at their roots short tentacles and a long tentacle. *Nectocalyces* nearly equal and similar; the proximal with two distinct cavities (the *hydrœcium* and *nectosac*), the distal with a single one (*nectosac*), with a round [pentagonal] aperture provided with pointed processes.

With the exception of the part referring to the nectocalyces these characters are common to *Diphyes* and all the other genera of the same order, and consequently they are not generic characters.

The *Physophoridæ* present a great variety in form, and are best represented by the genus *Physophora.* It differs from the genera of the *Calycophoridæ* in the way in which the two ends of the cœnosarc are modified, and in the disposition of the various appendages attached to the cœnosarc. A young *Physophora* is shown in *fig.* 18. It consists of a filiform cœnosarc, which is dilated at its proximal end; this dilatation, *e*, is the *pneumatophore*, a characteristic feature of the order; along the sides of the cœnosarc are a number of swimming cups, *g*, with small cavities or nectosacs; while its distal end is enlarged, and the polypites, hydrocysts, *h*, with their tentacles, *c*, are clumped together round this enlargement (*fig.* 18, and E. C. i. col. 40). The minute structure is essentially the same as in the other *Hydrozoa*, and need not be dwelt upon here. The pneumatophore of *Physophora* is believed to differ little from that of *Agalma* shown in *fig.* 19, in which it has an oval form, and, like the cœnosarc with which it is continuous, has walls of endoderm and ectoderm. Within this is a sac containing air, f^6, which is termed the *pneumatocyst.* This sac appears to be open below, but however this may be, its cavity does not open below, for the endoderm, *x*, which is reflected upon and closely adheres to its outer surface, does not stop short of the lips of the aperture, but extends completely over it. It is not tightly stretched over the aperture, but forms a sort of loose bag-like end, f^5, extending far below it. The contents of the pneumatocyst could be readily forced into this sac, but when the pressure was removed they would return again. The sac formed by the endoderm does not hang loosely and freely, but is connected with the walls of the pneumatophore by a number of vertical mesentery-like partitions. These terminate in free arcuated edges opposite the lower end of the endodermal sac (*Huxley*). The pneumatocyst has tough, strong, elastic walls, which are composed of a substance resembling, if not identical with, chitin. In most genera it is believed to be imperforate at its apex or proximal end, but in one or two, such as *Rhyzophysa* and *Physalia*, it is perforate; while in *Velella* and *Porpita* there are several openings connecting the pneumatocyst or air-bladder with the external medium. In no case is there any communication between the air-bladder and the cavity of the cœnosarc. In *Rhizophysa* the distal end of the air-bladder is covered with long branched processes, which project into the cavity of the pneumatophore. Each process is described by Huxley as having a cellular axis invested by a layer of endoderm; the cells of the axis are clear and contain an opaque smaller cell, within which is a minute particle, $\frac{1}{1250}$th of an inch in diameter. Nothing resembling these filaments are known in any other genus, and there is no ground for supposing they have any relation to the pneumatic filaments in *Velella* and *Porpita.* The pneumatophore and pneumatocyst are generally similar in shape. In *Rhyzophysa* they are spheroids; in *Physophora*, elongated ovals; in *Agalma*, cylinders, with narrow, inferior necks; in *Physalia*, irregular pear-shaped bodies; and in *Velella* and *Porpita*, flattened discs. Their size also varies, being small in proportion to the other parts in *Agalma, Physophora*, &c., which generally possess swimming cups; and large in *Velella, Physalia*, &c., in which the swimming bells are absent. In these latter genera the air-bladder is the most conspicuous part of the animal, and is far more complicated in structure than the smaller air-bladder of *Physophora*, &c. In *Physalia* the air-bladder is composed of two sacs, one within the other, the space between them being filled with a transparent fluid, and the inner sac communicating with the external medium by means of a pore. The cœnosarc appears to be absent, or, if present, is only represented by the dilatation around which the polypites and their accompanying appendages are grouped. In *Velella*, also, the cœnosarc appears to be absent, or else blended with the air-bladder. This latter is a horizontal rhomboidal disk, surmounted by a triangular crest, the apex of which is immediately over the centre of the horizontal disk. When floating on the surface of the sea this crest is uppermost, and from its lower side are suspended the polypites, &c. The polypites are of two kinds, viz., a single large polypite, which occupies a central position, and a number of smaller ones which are grouped round it. Both the disk and crest consist of two parts, one of which is hard and firm, and the other is membranous. The hard part owes its firmness to the body, which is commonly known as the *shell*, composed of a horizontal portion continuous with a vertical plate. On the upper surface of the horizontal plate is a groove which crosses the crest at right angles to its long diagonal. The horizontal division of the pneumatocyst consists of two thin laminæ passing into one another by their free edges, and united by a number of concentric vertical septa, between which are corresponding chambers filled with air. All these chambers communicate together by means of apertures in the septa. Of these each septum presents two, placed at opposite points of its circumference, and all nearly in the middle line of the pneumatocyst. Many of the chambers also have an opening communicating with the outer medium. These apertures are situated in the proximal or upper wall of the chamber, along a line about midway between that of the openings just described and that of the vertical plate of the pneumatocyst. The vertical plate is solid; the concentric markings on its surface are mere ridges and do not indicate septa. The substance of the pneumatocyst is not calcareous, as has been supposed, but, like the same part in *Agalma*, closely resembles chitin. The pneumatocyst is enveloped by soft parts, which possibly represent the cœnosarc; at any rate, whether it does so or not, it is traversed by a series of canals which anastomose so as to form a network of passages, the inner walls of which are ciliated. The distribution of the canals on the soft parts covering the crest is as follows. The innermost of the canals are nearly straight; the outermost are more or less curved in correspondence with the free margin of the crest. Branches proceed from them, some of which end in cœca, while others anastomose to form a network. Near the termination of the vertical plate the canals become wider and less distinctly defined, acquire a decided blue colour, and pass into a canal which runs along the line of junction of the vertical plate with the softer membranous fringe. From the outer side of this canal, again, branches are given off into the fringe, which run obliquely towards its margin, and in their course give off wide cæcal processes on each side, which rarely anastomose. Near the edge of the fringe the ends of all the branches are connected by a blue marginal canal, which gives off numerous short cæca on its outer side (*Huxley*). There are also similar canals in the soft parts covering the upper surface of the horizontal plates; and here also they form a network, accompanied by a marginal canal. All these canals communicate with other canals on the distal or under surface of the horizontal disk, and through them with the cavities of the polypite. These canals seem to correspond with the cavity of the cœnosarc in *Coryne*, &c., and also with the *chymiferous canals* in the disk of the *Medusidæ.* The pneumatophore of *Porpita* resembles that of *Velella* in enclosing a hard chitinous pneumatocyst, composed of air-containing foraminated chambers, communicating with one another and with the exterior, and of an investing soft part, traversed by anastomosing canals, which are in communication with the cavities of the polypites suspended on the lower sides of the flat horizontal disk.

The polypites do not differ greatly from those of the *Calycophoridæ*, and, like the hydrocysts and nectocalyces, do not seem to require any special notice; but somewhat must be said about the *hydrophyllia.* These organs are absent in a great many genera, and in those which possess them they present marked variations in their structure, the way in which they are attached, and in their relation to the other appendages. "In *Athorybia* they are foliaceous; in *Apolemia*, clavate; in *Agalma*, thick and wedge-shaped. Their surface is smooth in some genera, in others angular and ridged. Generally they are arranged in whorls. In *Apolemia* they are proximal to all the other appendages in each separate group, and here, as in *Halistemma* and *Stephanomia*, they become connected with the cœnosarc by more or less distinct peduncles. In *Agalma* the attached apex of each is pierced by a duct which terminates in a cæcal phyllocyst about the middle of the hydrophyllium, while its opposite end opens into the somatic cavity. In *Forskalia* the hydrophyllia are attached directly to the peduncles of the polypites. The graceful *Athorybia rosacea* possesses from twenty to forty of these organs, inserted in two or three circlets, immediately below the pneumatocyst, and above a much smaller number of polypites. In all other *Physophoridæ* with hydrophyllia, nectocalyces also are present; but *Athorybia*, though destitute of the latter appendages, has the power of alternately raising and depressing its hydrophyllia so as to render them agents of propulsion" (*Greene*).

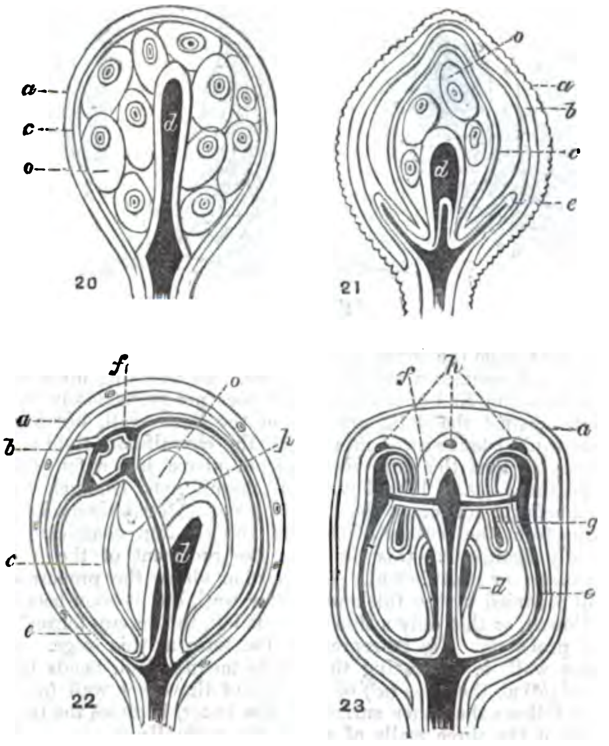
On referring to the definitions of the genera of the *Physophoridæ* in the article Acalephæ, E. C., we find that De Blainville, the author of most of them, entirely misunderstood the functions of the various parts. This may be illustrated by *Physophora*, which is thus defined: the terms in brackets are the modern synonyms. Body [cœnosarc] more or less elongated, cylindroid, hydatiform [pneumatophore] in its anterior [proximal] part, provided below with two series of vesicular diversiform bodies [swimming bells] with a regular aperture, and behind with a variable number of very diverse cirrhiform productions, two of which [long tentacles and hydrocysts] are longer and more complex than the others; mouth at the extremity of the hydatiform part; anus terminal. In this description the terms anterior and behind should be replaced by their opposites. That an accurate knowledge of the morphological position of the animal is essential to accurate definition is clear, for otherwise De Blainville would not have placed the mouth where he has. When the *Physophora* is floating, the air-bladder is uppermost, and when swimming, it is foremost; and hence it was, doubtless, concluded that this was the anterior end. In *Physophora* there is no aperture in the air-bladder, and consequently nothing that can be called a mouth; in some other genera there is an aperture, but, as we have seen, this communicates with the air-vessel only. The anus of De Blainville appears to be the oral aperture of the central polypite. Similar remarks apply to all the other definitions; and in some of them other errors require to be pointed out. The so-called branchiæ in *Physalia* are probably tentacles; the two orifices mentioned do not exist, and the so-called organs of generation have nothing to do with the reproductive process; the fibrillo-capillaceous plate in *Diphysa* is probably a hydrophyllium; the squamous organs in *Apolemia* are certainly hydrophyllia; there is no intestinal canal in *Stephanomia;* the gelatinous bodies in *Protomedea* are hydrophyllia.

The *Medusidæ* is the next order which calls for notice; but in order not to mislead, it may be at once mentioned that the great bulk of the species formerly assigned to it are now known to be the reproductive zooids of the *Corynidæ*, *Sertularidæ*, and other orders of *Hydrozoa;* and that there is little or no satisfactory evidence to show that any group of animals exist which produce eggs that develope immediately into medusæ, or rather that do not pass through an intermediate hydraform stage. If it should prove that all undergo transformation from an ova into a hydroid body, and then into a medusoid one, the *Medusidæ* will have to be abolished as a distinct order. And since the *Medusidæ* are morphologically and physiologically more highly developed than any of the hydroids, the distinctive characters of the orders would have to be based, not solely upon the hydroids, as at present, but more especially upon the medusoids. As perhaps we ought to be guided by the well-ascertained facts rather than the ill-ascertained ones, it will better suit our purpose to consider the *Medusidæ* as reproductive zooids. Their structure and modification of form will therefore be given in connection with the phenomena relating to generation. The *Lucernaridæ* will be better understood after the *Medusidæ* have been considered, and therefore the description of them is deferred until after the section on generation, which immediately follows.

Having thus briefly traced the development of the ova of the *Hydrozoa*, and the numerous modifications to which they give rise, we will now endeavour to complete the cycle of changes by dwelling upon the machinery connected with the formation of the eggs themselves. It has been already indicated that the normal result of a single egg is a long series of zooids of different forms, the earlier developed of which are non-sexual, while from them others arise by generation which are sexual. This is analogous to what occurs in plants, in which certain parts (leaves), solely devoted to the purposes of growth, are followed by others (flowers) mainly devoted to the formation and fecundation of the seed. In both the plants and animals the composite colony derives its form by a continuous process of gemmation or budding. In the *Sertularidæ* (*Laomedea flexuosa* for example), the first zooid is a simple hydra-like body, from a certain part of which there is protruded a hernia-like projection, which diverges at a certain angle, and ultimately becomes a polypite; this in its turn developes other polypites by gemmation. The *gonoblastidia*, or the modified polypites which carry the gonophores, are developed in precisely the same way as the nutritive polypite, up to a certain stage, viz., that at which the bud entirely fills the chitinous investment. For the sake of convenience, the term *reproductive polypite* will be used as synonymous with *gonoblastidium*, and *reproductive zooid* as synonymous with *medusa*. In the gonoblastidium bud the next phenomenon is the appearance of a number of cavities in the ectodermal layer; the cavities enlarge, meet, and by their union give rise to a canal which separates the ectoderm into two parts or layers. The external layer is attached to the chitinous capsule, while the inner one remains in connection with the endoderm. The endoderm is withdrawn upon the *blastostyle* or axis of the bud, so as to leave a large unoccupied cavity in the capsule. This space is subsequently occupied by the bodies which are developed from the blastostyle, which are the sexual zooids or gonophores. In *Hydractinia* we have the central column, from the sides of which are developed the gonophores or egg-containing zooid, but no enveloping chitinous capsule is formed as in *Sertularia.*

These gonophores are built upon the same plan as a gymnophthalmic medusa, but in some cases the plan is evident, while in others it is less evident, and hence the first has been called *phanerocodonic* or 'manifestly bell-shaped,' and the second *adelocodonic* or 'obscurely bell-shaped.' There is, however, no essential difference between them, for the one is only a higher development of the other; and the phanerocodonic gonophores are themselves in most instances thrown off as medusæ, which lead an independent existence, develope ova and spermatozoa, and die.

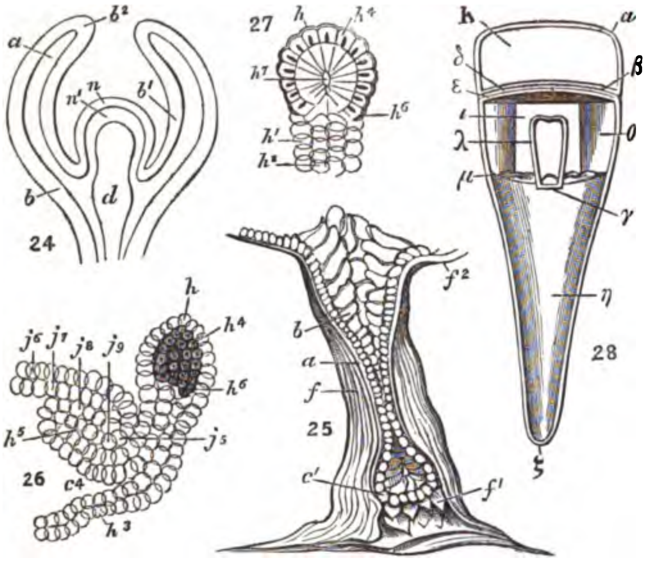
The adelocodonic gonophore is most easily studied in *Hydractinia echinata*, in which the gonophore arises from the side of the reproductive polypite (gonoblastidium); its first appearance consists in a bulging out of the ectoderm, *a*, *c*, *fig.* 20, and endoderm, the cavity of the bud being in direct communication with that of the reproductive polypite. The ectoderm separates from the endoderm, and the space between them is filled with the granular matter, from which the ova and spermatozoa are ultimately developed; subsequently, the ectoderm becomes differentiated into two layers. The gonophore enlarges with the growth of the spadix, *d*, and the increasing volume of the generative mass, *o*; the appearance of this mass soon indicates the sex of the gonophore, for in the male it is a uniform grumous plasma, while in the female the ova are plainly visible. This is the highest stage it attains in this species, a stage very similar to that of *Clava multicornis* (*fig.* 20); but in other genera the development is carried further. Thus, in *Garveia nutans* (*fig.* 21) there is a distinct mesotheca, *b*, in addition to the inner and outer membranes, and the four canals, *e*, radiate for a short distance from the base of the spadix; but the summit of the gonophore is still closed, and there are no traces of any circular canals. In a higher stage represented by *Tubularia indivisa*, the mesotheca is highly developed, and is perforated at its summit; the four radiating canals are much larger, and terminate in a circular canal, *f*, *fig.* 22. There is little difference between this and a true phanerocodonic gonophore, such as that of *Syncoryne eximia* (*fig.* 23), in which the mesotheca is a contractile locomotive swimming bell, with a well-marked aperture and veil; in which the manubrium is perforated by a



(After Allman.)

mouth; and ocelli, *h*, and tentacles, *g*, are developed. As the medusoid is no longer dependent on a nutritive zooid for nourishment, it is thrown off to lead an independent life. The same plan of development prevails throughout the *Hydrozoa;* this might be illustrated by the similarity in structure and development of the gonophores, or egg-bearing sacs of *Cordylophora*, &c.; of the *Medusoids* of the *Corynidæ;* and of the nectocalyces or swimming-bells of the *Calycophoridæ* and *Medusidæ;* but such a comparison would take up more space than we can afford.

As an example of the way in which the medusa is developed, we will take Agassiz's description of it as seen in *Coryne mirabilis.* The medusæ buds appear at two different seasons, viz., from January to April, and November. They originate from the head of the polypite, usually just below the tentacles, and are seldom more than five or six in number. They may be in different stages on the same polypite at the same time. The earliest indication of a medusa bud is a thickening of the exterior walls, so as to produce a slight papilla. This is followed by a corresponding thickening in the inner wall. Soon after both walls protrude perpendicularly from the head, as a blind sac which retains its communication with the digestive cavity. At this early stage the bud can contract and extend itself. At the next stage the inner wall recedes from the outer one at the apex, and assumes a cup-shaped form. In doubling upon itself the retreating fold of the inner wall does not press closely on all parts against the stationary part of the inner wall, but leaves four equi-distant spaces into which the chymiferous fluid penetrates, so that the cup viewed from above has a four-lobed appearance, each lobe having a chymiferous channel. The channels get longer as the cup deepens. After a time a hernia arises from the bottom of the cup, and the four channels press closely against it; this hernia is the rudiment of the future proboscis or manubrium. The portion above the proboscis is still occupied by the thickened outer wall, but it soon becomes hollowed, so that only a thin lining is left to the cup formed by the proboscis. *Fig.* 24 represents the form at this stage. The outer wall, *b*, embracing the whole medusa bud, bends upon itself (b^2) at the edge (a^3) of the cup of the inner wall (*a*); it then follows the inner surface of the latter, becomes the innermost of the three walls of which the umbrella is composed in the newly freed medusa, and passes to and over the proboscis (*n*), where it constitutes the outer wall. In this way the cup-shaped disk of the medusa becomes triple walled, *b*, *a*, b^1, and the proboscis double walled, n, n^1.



(After Agassiz.)

While these changes have been going on, others have occurred elsewhere. The radiating tubes have become broader, especially at a point about half way between the base and the extremity; by further broadening at this part each canal gives rise to two lateral sinuses, which ultimately coalescing with the lateral sinuses of neighbouring radiating canals, form a continuous channel connecting all the canals together, and constitute the circular chymiferous canal of the medusa. The contracting edge of the cup formed by the middle wall in the earlier phases, has in the present stage closed over the cup; and in doing so has separated the outer from the inner wall, thus severing their former connection. These three walls constitute the septum which prevents all communication between the outer medium and the concavity of the disk. The outer and inner walls are still much thicker than the middle one, which is much thinner than in the earlier phases. The tentacles next appear, and as they grow longer they are coiled up within the disk, any contact with the inner surface of the cavity and the proboscis being prevented by the transverse septum, and communication with the outer medium being prevented by the thin horny sheath enveloping the medusoid. The base of each tentacle is somewhat swollen, in consequence of a large cavity which exists there. The fluid in the radiating and circular canals is poured into this cavity, where it is kept in constant circulation. On the outer side of this swelling is a small black mass, occupying a position corresponding with that of the eye in the adult. At this time the medusoid possesses considerable motive power, as is evidenced by the contraction and extension of the proboscis, and the violent jerking of the disk. This jerking motion soon enables it to burst the horny film, and to expand its tentacles; the transverse septum is then perforated, the perforation gradually enlarges, and water is abundantly supplied to the concavity of the disk. This leads to increased activity on the part of the medusoid, which expels the water by the contraction of the disk, and sucks it in by the expansion of the same part. It is still, however, attached by a short peduncle, which gradually thins by wasting away; when the peduncle has become very thin, the medusoid's restlessness becomes greater; the vigour and rapidity of its jerks increase, and ultimately it succeeds in liberating itself as a medusa not more than $\frac{1}{16}$th of an inch in diameter. There is no trace of a nervous system, although there are certain appearances which have been mistaken by Agassiz and other observers for nerves. Agassiz himself points out that these so-called nerves are the optical expression of the innermost wall of the radiating canals when viewed in profile. The development of this medusa has not been fully followed out, but a number of transition forms have been collected at different times, which leave little doubt that it is the immature form of *Sarsia mirabilis. Sarsia* belongs to that group of jelly fishes which Forbes called *Steganophthalmata*, or naked eyed; they are marked by a certain simplicity of structure which strongly contrasts with the group which he called *Gymnophthalmata*, or covered eyed. The development in the species of the latter group differs considerably from what occurs in *Sarsia* and its congeners. *Aurelia*, the genus to which one of the commonest jelly fishes of the English coast belongs, will serve to illustrate the group generally. The English species is named *A. aurita*, and was elaborately described by Professor Ehrenberg more than thirty years ago in his account of the Acalephs of the Red Sea. There is a closely allied species, named *A. flavidula*, which appears to be the American representative of the genus, and which is the common form on the western side of the Atlantic, as *A. aurita* is on the eastern side. Both species are nearly coterminous in their range north and south, and both are replaced towards the southern limits of their extension by other but nearly allied species. The American species, *A. flavidula*, has been described and illustrated with remarkable fulness of detail by Professor Agassiz. The following remarks mainly refer to this species, and are for the most part given by Professor Agassiz. The development of the egg and embryo generally resembles that of the other *Hydrozoa.* The planula fixes itself by one end, soon after which the four tentacles appear. They generally commence in two tubercles, which are very shortly after followed by two others. These tubercles begin in mere thickenings of the outer wall, and look like small excrescences just behind where the mouth appears a few hours after. Immediately the mouth is formed it shows signs of activity by gaping, although no food is taken for a considerable period. The soft column and the base become invested with a layer of transparent amber-like substance, the representative of the horny sheath or polypary of the *Corynidæ.* As growth proceeds it thickens, and developes a laminated character, which clearly indicates that it is composed of a series of excretionary layers formed from the outer wall of the polypite. Soon after the appearance of the sheath the thread-cells are developed abundantly in the tentacles, which are now almost as long as the body. The outer wall at this stage is very thin, and is composed of a single layer of cells, except in the tentacles, which are almost entirely made up of a thickening of their outer walls, while the inner wall forms as yet only a short basal portion; the tentacles, even at this early stage, are remarkably extensile and contractile. The inner wall is thick and opaque, its interior surface is smooth and well defined, so that the digestive cavity is apparently quite fitted to commence its functions. The cells on the interior surface of the inner wall are indistinguishable from those of the outer walls, being, like them, simple, irregularly polyhedral, and indefinitely arranged. The cells in the outer wall of the tentacles gradually verge into one another, so that this wall from having a cellular, acquires a homogeneous structure. The inner wall rapidly developes, and soon takes on the form characteristic of the adult. In a somewhat older zooid the outer wall of the polypite still remains thin and transparent, but the cells of the inner wall have become quite different in form from those of the outer wall. They are now very large, of an irregular prismatic shape, and arranged with the long diameter transverse to the thickness of the wall—that is, at right angles to the axis of the zooid. It is five times thicker than the outer wall. The mouth also has undergone great changes. It is now not a simple slit, but quadrilateral, as if four-lipped; and each lip or lobe corresponds to a tentacle. At this phase it begins to catch prey. When the polypite is fully expanded it is semi-transparent, and of a uniform orange-greyish tint, the orange colour arising from the reflection of the pigment cells lining the digestive cavity. When the body is contracted these cells are packed more closely together, and the orange tint is deepened. In the next stage four more tentacles appear at points in the intervals between the first four. Their origin and growth is the same as in the earlier tentacles, and they become as long as the first four prior to a fresh set appearing. At this stage the zooid is remarkably like the fresh-water hydra in habit and form. The base is long and slender, and is not unlike a tentacle; the lobes of the mouth are very active, at one time being projected separately, and at another being projected when appressed together, so as to form a short proboscis. The mouth, however, is so variable in its shape, that no definite form can be readily assigned to it; but usually it is slightly raised above the bases of the tentacles, with each of its four corners projecting towards the base of a tentacle; frequently, however, there are three, five, or more corners, and these may point towards the tentacles or towards the spaces between them. The walls have about the same relative thicknesses as in the preceding stage, but the most noticeable new points are the following. The bases of four alternate tentacles are prolonged inwardly, so as to project like triangular buttresses into the digestive cavity. The breadth of these projections nearly equals that of the base of the tentacles, and they extend but a short distance downwards along the wall of the body. They are composed entirely of cells from the inner wall, and correspond in position with the bases of the first four tentacles. According to Siebold and Sars, they extend to the base of the digestive cavity, and according to Dr. Reid they are hollow; but Professor Agassiz denies the accuracy of these observations. As these observers doubtless examined the species of the sea coast nearest to them, and as the European and American species are not identical, it is possible that their observations in each case were correct for the species examined. The lobes of the mouth are double bordered at this stage, owing to the overlapping of the edge of the outer upon the inner wall. The lasso cells are not so generally dispersed, but are more concentrated around the mouth and in the tentacles. The horny sheath, *f*, *fig.* 25, is as well developed as in any of the hydroids of the naked-eyed medusæ, such as *Coryne* or *Tubularia*. The inner surface of the tube, as shown in *fig.* 25, does not quite touch the stem. At its lower end, it spreads out into a broad base, and is directly connected with the bottom of the pedicle, c^1, by several small slender conical props, f^1. Passing upwards, it thins out, and terminates just above the base of the cup-shaped head, f^2. This is the earliest period at which Professor Agassiz has seen the zooid take food. Some of the embryos are quite destitute of a sheath, and these are frequently found progressing from place to place on their tentacles, just like a fresh-water *Hydra*. In the next stage there are usually 16 tentacles developed, and this appears to be the normal number in *A. flavidula*, but occasionally there are 20. The buttresses remain constant in number, but acquire greater thickness and breadth. This constancy in number and position affords a ready clue in determining the ages of the tentacles in the adult zooid.

In this state the zooids remain for a certain period, each one giving rise to others by gemmation from the sides, or from detached portions of the base; and thus a closely crowded colony is formed. Professor Agassiz does not state at what period the zooid undergoes the changes which will be next described, but a colony of the English species, *A. aurita*, which has lived in an aquarium for several years, has given off medusæ at intervals of three years. Whether this is a normal phenomenon, or whether the throwing off of medusæ is more frequent in the sea-bred individuals, we have not been able to ascertain. However, at a certain age, and during the warmer months of the year, a well-marked constriction appears just below the tentacles, gradually deepens, and by the time it has extended about half way to the centre of the body, a second constriction appears at a distance below the first, about equal to the combined thickness of the walls of the body. This in its turn gradually deepens, and when it has reached about half way towards the centre, a third constriction appears; and this process is continued until about 13 constrictions have been formed. While the lower constrictions are forming the upper segments are undergoing certain changes. The uppermost segment bears the tentacles, and does not change; and the second segment is always more forward than any of the others. As the changes are the same in all the segments, we shall confine our attention to the second segment only. When the constriction has penetrated a certain depth, the edge of the segment becomes first wavy, and then deeply notched, while the segment is divided into eight lobes, arranged at equal distances, and separated by sinuses which occupy as much space as the lobes themselves. The segment becomes somewhat depressed in the centre, so that it has a shallow saucer-shaped figure. The eight lobes soon become pointed, or rather papillate, and increase in width, so that they soon occupy more space than the intervals between them. The papilla acquires a definite outline, and increasing in size, appears like a lobule at the end of the larger one. Soon after the large lobe expands on either side of the lobule, and while the lobe as a whole increases in size the terminal projections also become more and more prominent until they form oval lappets as long as the main part of the lobe itself. At this stage the shape of the lobe might be roughly compared to a broad Y, the shank being the main part of the lobe, and the two branches or forks the lappets. The lobule will occupy the angle of the fork. After this the whole lobe elongates, the main part broadens, and the lobules lengthen. The lappets also broaden midway, and become abruptly pointed. The lobule becomes twice as long as broad, and partially hidden by the overlapping of the edge joining the two lappets. The lobes soon attain their greatest proportional length, and the lappets their widest expanse individually. The proboscis is four sided, and its corners project beyond the general outline. The digestive cavity extends by means of broad straight shallow channels to the base of the lobe, and also to each papilla. Near the base of the proboscis, and opposite each flat side, a group of four or five digitate bodies project into the digestive cavity. Just before this stage it is usual for the segment to commence a violent jerking movement, which it repeats at frequent intervals, which become shorter and shorter until it has effected its release, and has become an actively swimming independent zooid. All the other segments pass through the same changes, and each in turn liberates itself. So far as we know, no observer has been able to detect how the first medusoid (as each segment is called while attached) separates itself from the one below it. Agassiz suggests that the constriction cuts through where the lip of the proboscis of the lower one is fixed to the disk of the one above it. In a previous part of this article it was stated that the upper side of the medusa was the proximal side, and corresponded with what is the lower end of a hydra when attached to the upper surface of a stone. The position of the segment or medusoid is one of the facts which proves this. In developing it will be recollected that the segment acquired a saucer-shaped form, with the concavity uppermost; the proboscis is attached to the centre of this hollow, and projects distally. The motion of the medusoid consists of an expansion and contraction of the saucer-shaped cavity. The moment it effects its release, the medusoid, in the great majority of cases, turns over, and ascends towards the surface by what appears to be a sort of flapping action. The proboscis is now undermost, and is generally so; the upper side, then, is that which in the hydra form was proximal, or nearest the point of attachment. In the E. C. vol. i. col. 26, the reader will find figures of the constricted hydra form, the cup-shaped medusoids with their lobated margins, and the newly liberated medusa, with its furcated lobes, its quadrilateral polype mouth, and what is intended for the group of digitate appendages opposite the flat sides of the mouth. The lobule is not shown.

The connection between these stages was not known to the earlier observers, and hence their marked differences caused them to be regarded as distinct genera. The names are still used occasionally for the purpose of specifying the stage. The earliest stage is called *hydra;* the second, with the cup-shaped segments, *scyphostoma*, or *strobila;* and the newly liberated medusa, *ephyra*. The *ephyra* is the same as the adult, but with its parts less developed. Thus the eight lobes correspond to the oculiferous lobes of the full-grown forms, and the lobule is the rudimentary ocular peduncle. The intervals between the lobes represent the tentaculiferous edge; and the broad papilla in each of these intervals, the marginal veil. The digitate bodies are the genital appendages. A few terms new to the reader are here mentioned, but they will be explained more fully presently.

The young medusa has a diameter of about the third of an inch, and is in constant activity. Locomotion is effected by the alternate contraction and expansion of the concave disk, which from its form is frequently called an *umbrella*, but this form is not so conspicuous in the young as in the adult medusa. The medusa is very nearly of the same specific gravity as the water, and its habit is to make a few rapid, vigorous strokes until it reaches the surface of the water, when it spreads out its lobes as widely as possible. The consequence is that it sinks very slowly, partly owing to the spread-out form giving greater resistance to descent, and partly to its reducing the specific gravity of the animal. If alarmed the medusa contracts itself into as small a space as possible so as to hasten its fall to greater depths.

The young medusa undergoes rapid changes in form and proportion. The oculiferous lobes broaden in proportion to the expansion of the body, and soon occupy two-thirds of the whole circumference. The disk grows faster than the proboscis, which consequently appears to become smaller. The digestive cavity occupies the great bulk of the disk, and canals extend from it to the base of the eye pedicles, and other canals pass to that part of the disk's edge that bears tentacles. The digital appendages are doubled in number, and are seen to be deep pouches formed by a continuation of the inner wall of the digestive cavity, and opening into the space between the two walls. The eye pedicles are attached obliquely to the disk, and in such a way that the curved pedicle projects upward and outward so as to be in a position to see objects above the disk. (*Fig.* 26.)

In the next stage the tentacles appear, as also another row of eight generative appendages. The latter are arranged in a curved line a short distance nearer the margin of the disk than the first row; they communicate with a narrow curved furrow parallel to a second and broader furrow. The radiating canals are now united by lateral passages, which together form the continuous passage round the edge of the disk, which is usually called the *marginal* or *circular* canal. At this stage the marginal veil is plainly visible as a broad, tongue-shaped membrane extending across the interval between the eye pedicles.

At a still higher degree of development the marginal veil becomes still more prominent, the round corners of the proboscis become converted into straight ones as if cut across, and the lips of the proboscis become thinner, nearer, and more trumpet-formed. The four buttresses stand out conspicuously at the four corners, and their bases extend as far as the digestive cavity. The radiating canals, which were straight, are now somewhat branched, the branches being formed by the separation of the upper and lower floors of the disk. The eight canals leading to the eyes are markedly different in form from those leading to the tentacle-bearing margin. The former have an equilateral triangular outline, while the latter have straight parallel sides. The eye is well developed, and is better examined at this stage than any other, since it soon after loses the transparency which it has during the earlier stages of development. It has long been an interesting subject of discussion amongst zoologists whether the so-called eyes of jelly fishes were really organs of vision or not. The evidence brought forward in Professor Agassiz's work seems to leave little doubt on this point. The facts are drawn entirely from *Aurelia flavidula*, but as they probably represent what may be seen in many other genera we will give the details somewhat fully. The pedicle has a peculiar oblong cylindrical shape, which is broader in the lateral than in the vertical aspect. In the first aspect it has the form of a long oval with a broad base, while in the other, *fig.* 26, it resembles a slightly bent finger. It is usually turned upwards between the lappets of the lobes, and slightly raised above the edge of the disk, but sometimes it is withdrawn under the lobe. The pedicle has two walls, h^1 h^2, *fig.* 27, directly continuous with those of the lobe from which it arises; in fact the eye pedicle is simply a solid organ occupying the place of a tentacle suspended from the under surface of the oculiferous lobe. The outer wall of the pedicle has the same thickness as that of the lobe, except at the end, where it thins out in passing over the tip. In profile also it resembles the outer wall of the lobe, j^7 j^8, *fig.* 26, except near the end (*fig.* 27, h^4 h^6 h^7), where it suddenly increases to a thickness twice as great as is met with near the base of the pedicle. In the view from above it shows a sudden increase in thickness at the base, but thinning towards the middle, and again thickening at the end as in the profile view. The cells of the two walls of the pedicle generally resemble each other in corresponding positions, but they are different in one part than another; those of the eye especially have a peculiar form. The cells of the outer wall, h^1, as well as those of the lobe, j^6, resemble broad polygonal prisms placed side by side in a single layer; their contents are homogeneous and transparent, nor do they appear to have any mesoblast, or smaller cells. At the base of the eye (*figs.* 26 and 27) they decrease more or less in length according to the degree of expansion of the pedicle. Sometimes they gradually decrease in length (*fig.* 27), and are distinguishable at the end of the facets, but oftener their length suddenly decreases, and forms a thin layer of thin polyhedral disks over the eye. The cells of the inner wall are also prismatic (*figs.* 26 and 27) variable in length, and of various aspects in different parts. In profile (*figs.* 26, 27) they resemble those of the outer wall, but when viewed from below they have a more prismatic columnar appearance. In either case they rapidly increase in length after entering the facetted eye, and acquire a polyhedral conical form (*fig.* 27, h^4 h^7) and a converging arrangement. At the base (h^6) of the facets their conical form is not so apparent, but a little beyond this they are strictly conical, and all have the apex at the centre (h^7) of the sphere. At this part another element appears in the form of a dark and highly refractive body which occupies about one-fourth of the outer end of each cell. When seen in certain directions it looks like a thin wall, but a closer examination shows it to have the form of a plano-convex lens (*fig.* 28, θ ι); the convex face β is turned towards the outer end of the cell, and the flat face μ towards its base ζ; the edge has a polyhedral contour, and generally has six sides, each of which sides fits accurately against the several sides of the cell, $\delta\eta$. In consequence of the lenses having a spherical contour these sides are not parallel to the axis of the lens, but converge slightly from the anterior convex face backwards, so that when viewed from behind they appear to have a double outline ι. The anterior face β is separated from the outer end of the cell ϵ by a shallow space δ. The hindermost of the flat faces is perforated by an aperture γ leading into the cavity λ which occupies the axis of the cell. This cavity is about one-fourth the diameter of the cell, and its sides run parallel with those of the cell. When seen from behind this cavity appears to be divided into several compartments, but the lines which give this appearance are superficial, and confined to the flat face of the sides. When the eye is cut through the lenses drop out, and by careful manipulation they can be turned about and an accurate idea formed of their shape. Judging from the habits of *Aurelia* and other Acalephs it might be inferred, indeed it has been proved, that these creatures have a perception of light, if not endowed with vision, or the power of perceiving objects. The organ which we have described appears to have everything essential for producing a distinct image, and is therefore strictly speaking an eye. Nevertheless it is difficult to decide if the medusa has the power of perceiving such images, for as yet no trace of any nervous system has been discovered. Notwithstanding this important apparent defect the fact that such beings are gifted with what has every appearance of being an elaborate piece of optical mechanism would incline us to believe that there is some substitute for the nervous system which has not yet been detected, whereby the full benefit of the organ is obtained, rather than to suppose that they have eyes and yet cannot use them. If the eye of *Aurelia* be compared with that of man as described under EYE, E.C. it will be seen that the mechanism is in both cases subservient to the same general principles, and are made up of parts, which correspond to each other in function and position. The following is the interpretation given by Professor Agassiz. First we have the cell of the outer wall (*fig.* 28), with its outer face, *a*, for the cornea, and its cavity, κ, for the anterior chamber of the aqueous humour; then the posterior wall β of the same cell, and the anterior wall ϵ of the cell η, containing the lens, combined would correspond to the membrana papillaris, which is imperforate, as in the embryo of many of the higher animals. Proceeding from before backwards we come to the space δ, which corresponds to the posterior chamber of the aqueous humour, or that which exists between the iris and the crystalline lens. Then we come to the crystalline lens θι, and finally the contents of the cell behind, η, correspond to the vitreous humour. As in the human eye the lens is a plano-convex one, that is, the anterior curve is much flatter than the posterior one, but in the human eye the flat side is foremost, while in *Aurelia* it is hindermost. In *Aurelia* the focus is situated at the bottom of the cell at ζ. Nothing is known as to the function of the cavity λ, which does not appear to be represented in the eyes of the higher animals. The eye of *Cyanæa* is similar to that of *Aurelia*, and probably the eyes of all the naked-eyed medusæ agree with it in the more essential details.

In the next stage of development the principal changes are that the marginal spaces become as wide as the oculiferous lobes; that the distal end of the proboscis acquires two filament-like prolongations; and that the proboscis shows traces of a longitudinal folding into four distinct lobes. The disk rapidly increases in diameter, and the indentations become more and more indistinct, so that the disk may be said to be circular in outline.

Soon after this the special characteristics develope themselves rapidly. The marginal veil still continues to be prominent; the fringes at the end of the proboscis become longer and more complicated; the proboscis itself loses its thick heavy character, and becomes a thin-walled body, having a graceful elongate, trumpet-shape, divided into four flexible lobes. The sexual appendages increase in number and volume, and the marginal intervals now occupy nearly twice as much of the circumference as the eye-bearing lobes.

As development proceeds change follows change, and every change leads us nearer to the final result. The young medusa, now about half an inch in diameter, has the marginal intervals more than twice as extensive as the eye-bearing lobes. Each interval now has about 14 tentacles, the marginal veil continues to increase proportionally as fast as the marginal intervals; the eight radiating canals opposite to, and half way between, the reproductive organs, are forked from four to six times; the digitate appendages are far more numerous, and the pouch beneath them is proportionally half as deep as in the adult; and the fringe margin of the proboscis extends half way to the margin of the disk.

When the medusa is one inch in diameter the marginal intervals, or those which bear the tentacles, occupy fully two-thirds of the circumference, and the tentacles in each segment number 32; the eye-bearing lobes are as broad as they are long; the plicated concentric folds cover fully one half the diameter of the disk, and extend very closely to the borders of the digestive cavity; the space occupied by the branches of the forked radiating canals extends as far along the circular canal as the length of the branches themselves, and therefore it has the form of a triangle with a broad base; the pouch beneath the sexual organs is proportionally twice as broad as in the last stage, and projects much upwards and towards the centre of the disk; and finally, the lips of the proboscis are very deeply fringed, and the furrows in the prolongations of the corners are very deep. It is not necessary to follow the changes further, since there is little difference between the medusa in this stage and in its adult condition beyond dissimilarity of size.

The foregoing details will assist us in understanding the structure of the fully developed *Aurelia*, which may be considered as a fair representative of the *Acalephæ* generally. The most prominent features in the adult are a beautifully hyaline faintly-coloured semi-transparent disk of a somewhat flattened shape (resembling that of the open part of a parasol), and having the margin marked by a few shallow equidistant indentations. From the distal, or what is usually called the lower surface, and around the central part of it, are suspended a number of digitate bodies, or finger-shaped appendages, arranged in the form of four crescents, and four conical processes, with crimply wavy edges. Generally speaking, the creature has eight indentations, four crescent-shaped bodies, and four large appendages, and it may be looked upon as being composed of four parts, all precisely alike, arranged round a common centre. The four large appendages are the four prolongations of the angles of the proboscis, and in the intervals between them are the four crescent-shaped bodies or genital pouches. In each of the four parts there are two marginal indentations, of which one is in a line with the corner of the mouth, while the other is opposite the centre of one of the genital pouches. The line between the corner of the mouth and a marginal indentation is occupied by a straight canal, while canals of a more complicated nature radiate from the genital pouch. The pouch forms an enlarged cavity, from the outer walls of which arise several tubes, of which the central and the two extreme lateral ones proceed direct to the margin, while the others intercommunicate by lateral branches. The central canal proceeds to the eye. There are many analogous points between this arrangement and that found in Echinoderms.

The furrows in the lobes of the mouth are almost obliterated in the adult, and the only connection with the digestive cavity is by narrow grooves and small apertures formed where the two sides of the lobe have not quite closed together. The ovaries and spermaries entirely fill the space between the lobes, and are so arranged that the eggs can only pass into the genital pouches. From them they are discharged into the digestive cavity, and along the grooves in the lobes of the mouth, to be finally deposited in little hollows formed by the folds in the substance of the lobes. The eggs accumulate in the lobes, pass through their earlier stages of development, and are released as planulæ when the lobes decompose after the death of the medusa. The medusæ are monosexual both in *Aurelia* and many other genera. In *Aurelia* the females are distinguished by their stouter oral appendages, their more rounded dorsal outline, the more intricate folding of the marginal fringes of the lobes, and by the lobes being coiled and far less pendant. At the spawning season the most marked distinction between the sexes is in colour, the ovaries of the female having a yellowish, while the ovaries of the male are purplish.

The group that embraces *Lucernaria* and its allies is the only one that now remains to be considered. It has been recently studied by Professor H. J. Clark, who has proposed to raise the genus *Lucernaria* to the rank of an order, under the name *Lucernariæ*. Although we have placed this group last, it must not be considered as the most specialised of the *Hydrozoa*. On the contrary, it appears to combine the general features of several of the other groups, both in structure and in habits. An account of the *Lucernariæ* will be found under LUCERNARIADÆ, E. C., which will give a generally correct idea of the external, but many of the details respecting structure require supplementing, since the relations of the *Lucernariæ* are with the *Hydrozoa* rather than with *Actinia* and its allies. The campanulate disk is homologous with the same part in the medusæ, while the pedicle corresponds to the same part in the hydra form, or the earliest stage of the medusæ. Associated with this combination of parts is the power they have of being sedentary at one time, and locomotive at another. It may also be noticed that the attached end is the proximal one; it is usually the lowermost when the animal is fixed, but when it is progressing from place to place either by means of its tentacles or by the pulsations of its campanulate disk, it is generally uppermost. The word inferior is evidently apt to mislead unless the position of the animal is defined, an ambiguity which does not attach to the word proximal.

The pedicle is hollow, and may contain a single cavity, or be divided into four cavities or chambers by longitudinal septa. The disk also is hollow, and contains the digestive cavity; both its proximal and distal walls are composed of three layers, of which the inner and outer correspond to the endoderm and ectoderm. The middle layer is largely developed, but it presents characteristic differences in the proximal and distal walls (or as Clarke and Agassiz term them, *aboral* and *oral*). In the proximal this middle layer has considerable thickness, but, according to Clarke, it is not contractile, although it is remarkably elastic. It is continued downwards into the pedicle. In the distal wall it is contractile, and it preserves this character in its continuation into the tentacles and marginal anchors. The cavity of the disk is partitioned into four chambers by the union of its two walls along four equidistant lines, which cavities are continuous with those in the pedicle. In one group (*Eleutherocarpidæ*) of the *Lucernariæ* these chambers extend uninterruptedly from the base of the quadrate mouth (which part corresponds to what has been termed the proboscis, or manubrium, in the medusæ, and the post-buccal cavity in polypites), to that part of the margin of the disk which does not bear tentacles. In another group (*Cleistocarpidæ*) there is a membrane in each chamber nearly parallel to the two walls, which stretches from the point where the polype-mouth unites with the disk to nearly half way towards the margin of the disk. A portion of the cavity is thus divided into two superposed parts, of which the proximal one only leads to the corresponding cavity in the pedicle; the other terminates in a *cul-de-sac* at the base of the polype-mouth. When the cup of a *Lucernaria* is looked into four depressions are seen, which correspond to the partitions between the chambers, and four elevations, which constitute four buttress-like masses diverging from the four angles of the quadrate polype-mouth. These buttresses have the same relative position as the same parts in the hydra form of *Aurelia*, and the four chambers correspond with the four radiating canals which extend from the corners of the mouth in the medusa stage. In the *Lucernariæ* the areas of the depressions mark the places of the four stronger muscular bands, and the elevations those of the weaker set. The muscular layer terminates in a marginal band of varying breadth and thickness, which forms a ring passing just outside the bases of the tentacles. There are eight groups of tentacles on the margin of the disk, and in each group the outermost row are the oldest. They somewhat resemble those of *Coryne* in being hollow, cylindrical, slightly tapering, and in terminating in a globular expansion, which probably serves as an organ of touch. The margin between the tentacles is sometimes simple, but sometimes it bears in young individuals eight tentacles, of which four are immediately opposite the corners of the polype-mouth, and four opposite the partitions. In older individuals each of these tentacles has a number of adhesive vesicles, which give it a modified form, depending upon the species. Thus in some it is pistilliform, in others bean-shaped, in others trumpet-shaped, but in all it is used as an organ of adhesion and progression; in this respect it is analogous to the base of the pedicle. These organs are distinguished by the term marginal anchors. In them, as in the tentacles, the motive power is derived from the layer of longitudinally fibrillated muscles situated between the inner and outer walls. The pedicle also has its muscular system, which is either imbedded in the gelatinous substance of the middle walls or stands out as prominent ridges on the inner face of it. In both cases it is composed of four longitudinal muscular cords extending from the base of the pedicle to its summit, where they merge into the muscular layer of the disk. The sexes occur in different individuals, but the organs of generation have the same position and structure in both. They consist of small sacs arranged in variously shaped groups on the inner wall of the distal side of the disk. Each individual has eight groups, one situated on each side of every partition. Each two separated by the partition form the halves of a genital organ, a feature which distinguishes this order from *Aurelia* and its allies, which have single generative organs. Each double group somewhat resembles the letter U in shape; the two branches extend most of the way towards the tentacles or the intertentacular margins. On the inner or convex edge of each double group are one or more rows of ligulate filamentary bodies partially covered with vibratile cilia, and partly with adhesive vesicles precisely similar to those on the marginal anchors. They are also studded with lasso cells similar in form to those of other *Hydrozoa*.

The following is James Clark's classification of this order:—

Family I. CLEISTOCARPIDÆ.

The neighbouring halves of adjoining genitals approximate each other, and unite at their distal ends opposite the corners of the quadrate mouth, and extend to or towards the four intertentacular margins which alternate with the partitions; the approximate genital halves, from their axial to the distal end, are united by a transverse horizontal membrane which divides each of the four quadrant cameræ of the disk into two superposed spaces, the oral one of which forms a *cul de sac*, or claustrum (hence the family name, from κλείω, I confine, and καρπὸς, fruit), opening at the axial end, and includes the genitalia.

Genus 1. *Halimocyathus.* Disk infundibuliform, octahedral; arms produced; pedicle tetracamerous; tentacles in groups at the end of the arms, outer row pistilliform, like the marginal anchors, radial development of the group greater than the transverse; marginal anchors pistilliform; genital bands transversely folded, united at their proximal ends across the end of the intervening partition, their distal ends reach nearly to the marginal anchors; the digitate bodies do not extend across the proximal end of the partitions; muscle of the pedicle four filaments, alternate with the four cameræ; principal muscles of the disc, eight ligulate bands arising from the proximate ends of the partitions, extend to the end of each arm; marginal muscle broad and thin, forming a sort of velum which projects beyond the margin of the aboral side; at the end of the arm it merges into the ligulate muscles of the oral side of the disk; gelatiniform layer of the aboral side, and of the pedicle, continuous. Comprises one species only, *H. platypus.* Found off Massachusetts.

Genus 2. *Craterolophus.* Disk octahedral, campanuliform; arms produced; pedicle monocamerous, the camera possessed of ridges which form a cruciate figure at its base; tentacles in groups at the end of the arms; anchors none; genitals tubiform, with blind sac-like divisions; pedicle muscles correspond to the four ridges in the camera. Two species known, *C. Tethys*, from the North Sea, and *C. convolvulus*, from the coast of Britain. The last is the same as *Lucernaria campanulata* of Johnston.

Genus 3. *Manania.* Disk urnæform, octahedral; the arms produced; pedicle monocamerous; the camera simple; tentacles in groups at the end of the arms, but a little within the muscular margin of the bell; outer or distal row pistilliform; the radial diameter of the groups greater than the transverse; marginal anchors pistilliform, situated just within the muscular margin; genitals transversely folded, terminating at a greater or less distance from the margin of the bell; the digitiform bodies accompany the united bands across the proximal end of the partitions; muscles of the pedicle four, equidistant, embedded in the gelatiniform layer; principal muscles of the disk ligulate; from each end of the proximal end of a partition one extends in a direct line to the end of the nearest arm; marginal muscle ligulate, powerful, forming a ring of uniform breadth and thickness uninterruptedly all round the margin of the bell, just outside the anchors and the tufts of tentacles; gelatiniform layer variable in thickness in the bell, uniform in the pedicle. One species, *M. auricula.* This is the *Lucernaria auricula* of many authors. It has been found off Greenland, Norway, and Maine.

Genus 4. *Carduella.* Disk urnæform, perfectly circular; arms none; pedicle tetracamerous; tentacles placed in eight distinct equidistant groups within the margin of the urn, and arranged in rows parallel to the margin, those in one row alternating with those in the next, and successively diminishing in size from the central to the outermost ones; the radial development less than the transverse; between every radial row the oral and aboral sides of the urn are united by a septum, so that the interior of the tentacles communicates with the quadrant camera of the urn through short radiating passages; the marginal tentacles are single tentacles, whose cavity opens between a pair of septa like those at the base of the tentacles; they are set up higher and nearer to the edge of the urn than are the tentacles; the approximated genital halves, with their respective claustra, extend half way or more towards the edge of the urn, transversely plicate; the digitiform bodies border the whole length of the bands; pedicle muscles four, alternate with the cameræ; principal muscle of the oral side of the arm pennate, the partitions forming the line of divergence; marginal muscle a single ligulate ring, forming a continuous thickened projecting brim to the urn, outside the tentacles and anchors; gelatiniform layer conspicuous, varying in thickness in the urn and pedicle. One species, *C. cyathiformis*; found on the coast of Britain. It is the same as the *Depastrum cyathiforme* of Gosse and the *Lucernaria cyathiformis* of Sars and Greene.

Family II. ELEUTHEROCARPIDÆ.

Each genital half projecting freely into the discal cameræ, extends in a direct line from the inner or axial end of a partition to or towards the end of an arm; the four quadrant cameræ of the disk simple.

Genus 1. *Lucernaria.* Disk broad, funnel-form; the eight arms elongate in closely approximated pairs, so that the oral side of the disk appears quadrate; pedicle monocamerous; tentacles in groups on the end of each arm; radial and transverse development of each group equal; marginal anchors none; genitals transversely folded bands, which extend to the end of the arms; muscles of the pedicle four, equidistant, projecting-like ridges or pilasters from the surface of the cameræ; the principal muscles of the disk ligulate, each one extending from the proximal end of a partition to the end of an arm; marginal muscle ligulate, very thin at the base of the tufts of tentacles; gelatiniform layer thin in the disk, moderately thick in the pedicle. One species, *L. quadricornis* of Müller and most writers. It is the same as the *L. fascicularis* of Johnston and others. It is widely distributed, occurring in the shallow seas off Denmark, Norway, Zetland, Faroe Islands, Greenland, Grand Manan Island in the Bay of Fundy, and Owl's Island in Massachusetts Bay.

Genus 2. *Calvadosia.* Disk infundibuliform; the eight arms nearly equidistant, prominent; pedicle monocamerous, with four equidistant rounded pilasters; tentacles in groups on the end of the arms, close to the aboral edge; outer row pistilliform, and having the same function as the anchors in other genera; radial and transverse diameter of the group equal; anchors none; genitals transversely folded; bands extending to the ends of the arms; the digitiform bodies alone extend across the proximal end of the partition; muscle of the pedicle a continuous thin layer of transversely disposed fibrillæ, forming a cylinder between the outer and inner walls, and embedded in the gelatiniform layer; the principal muscles of the disk ligulate, each one extending from the proximal end of a partition to the end of an arm; marginal muscle ligulate, moderately thick, but at the outer base of the tufts of tentacles very thin; gelatiniform layer thickest at the edge of the disk, but thins out almost entirely half way towards the pedicle, and then in the latter grows thick again where it is divided into two layers or concentric cylinders by the intervening muscular cylinder; the four pilasters are also gelatiniform, and not muscular, as are the pilasters in the pedicle of *Lucernaria quadricornis*. One species, *C. campanulata*. It is the same as that called *Lucernaria campanulata* in the E. C. It has been found at Calvados, France, and various localities on the English coast.

Genus 3. *Haliclystus*. Disk umbellæform; arms more or less prolonged; pedicle tetracamerous; tentacles all alike, in groups at the end of the arms; the radial and transverse diameter of the groups equal; marginal anchors pistilliform or fabæform; genitals double; the halves of each genital distinct from each other, the space between their proximal ends occupied by the digitiform bodies; each band extends to the base of the tentacles; the saccules distinct and prominent: pedicle muscles four distinct equidistant cords, alternating with the four cameræ, principal muscles of the disk pennate, diverging on each side of the partitions; marginal muscle a band of varying breadth, very thin at the base of the tentacles and anchors; gelatiniform layer of varying thickness in the disk; very thick in the pedicle, occupying all the space not appropriated for the four cameræ and the four muscular cords. Three species, *H. auricula*, *salpinx*, and *octoradiatus*. The first is found on the English coast, as also off Norway, Greenland, Anticosti Island in the Gulf of St. Laurence, and in Massachusetts Bay; the second is found off Maine; and the third is the *Lucernaria octoradiata* of Sars and Keferstein.

The recognition of the polymorphic development of the members of this class has rendered it necessary that all the forms should be taken account of in a natural classification. This has been partly done by M'Crady and Agassiz, but more fully by Allman, whose synopsis we give below. In it he uses several terms which have not been explained in a former part of this article. He calls those zooids which are specially organized for nutrition *trophosomes;* and those which are directly concerned in ovular reproduction *gonosomes*. These terms correspond roughly to what are frequently designated the *hydraform* and *medusaform* conditions. *Hydrocaulus* is that portion of the cœnosarc which intervenes between the polypites when spaced apart. *Codonostome* is the aperture of the umbrellas, when not sufficiently large to permit of this cavity being used for locomotion. The generic name adopted is that which was first employed, the gonosome and trophosome being regarded as essentially one in a classificatory point of view. The synopsis only concerns itself with those genera which belong to the orders *Tubularia* and *Campanularia*.

The number of species in each genus is that known to Allman in 1864.

ORDER I.—TUBULARIA.

Family 1. *Clavidæ*.

Genus 1. *Clava*, Gmelin. *Trophosome*.—Cœnosarc consisting mainly of a filiform hydrorhiza entirely invested by a chitinous periderm; hydrocaulus rudimental, and consisting of very short, simple, tubular processes from the free surface of the hydrorhiza, invested, like the hydrorhiza, by a periderm, and carrying the polypites on their summit. Polypites claviform, with scattered filiform tentacula. *Gonosome*.—Gonophores adelocodonic, sessile, or on very short peduncles, borne on the body of the polypite at the proximal side of the tentacles. Seven species.

Genus 2. *Tubiclava*, Allman. *Trophosome*.—Cœnosarc consisting of a well developed hydrocaulus in the form of simple or branched stems, which are given off at intervals from a creeping filiform hydrorhiza, the whole invested by a chitinous periderm. Polypites borne on the summit of the hydrocaulus, claviform, with scattered filiform tentacula. *Gonosome*.—Gonophores adelocodonic, consisting of clusters of sporosacs, sessile on the body of the polypite at the proximal side of the tentacula. One species.

Genus 3. *Campaniclava*, Allman. *Trophosome*.—Cœnosarc a creeping, filiform, ramified hydrorhiza, invested by a periderm; hydrocaulus undeveloped. Polypites sessile on the hydrorhiza, claviform, with scattered filiform tentacula. *Gonosome*.—Gonophores phanerocodonic, sessile on the creeping hydrorhiza; umbrella, at the time of its liberation, deep bell-shaped; manubrium simple mouthed, shorter than the height of the bell cavity; radiating canals four; marginal tentacles two, continuous with two opposite radiating canals, and having bulbous bases without distinct ocellus; two intervening smaller bulbs corresponding to the other two radiating canals in the circular canal. This diagnosis is based upon gonosomes, which are not fully grown. It is probable that in maturer individuals two additional tentacles originate from the intermediate bulbs, and that other changes may take place. One species.

Genus 4. *Turris*, Lesson. *Trophosome*.—Cœnosarc invested by a periderm, and consisting of a creeping filiform hydrorhiza, with a rudimental hydrocaulus, which forms very short tubular processes, supported on the free surface of the hydrorhiza, and carrying the polypite on their summits. Polypites claviform, with scattered tentacula. *Gonosome*.—Gonophores phanerocodonic. The mature *Medusa* has a sub-cylindrical umbrella, with four or eight longitudinal bands; manubrium massive, with a four-tipped mouth; radiating canals four; marginal tentacles numerous, each with a bulbous base, having a distinct ocellus. One species.

Genus 5. *Cordylophora*, Allman. *Trophosome*.—Cœnosarc a creeping filiform hydrorhiza supporting a well-developed branching hydrocaulus, the whole invested by a chitinous periderm. Polypites fusiform, developed from the extremities of the branches; tentacula filiform, scattered on the body of the polypite. *Gonosome*.—Gonophores adelocodonic, borne on the hydrocaulus, never on the polypite. Two species.

Genus 6. *Corydendrium*, Van Beneden. *Trophosome*.—Cœnosarc consisting of a rooted and branching hydrocaulus, invested by a periderm. Polypites developed from the extremities of the branches, fusiform, with scattered filiform tentacula. *Gonosome*.—Gonophores phanerocodonic, developed from the cœnosarc. Form of medusa unknown. One species.

Family 2. *Podocorynidæ*.

Genus 1. *Stylactis*, Allman. *Trophosome*.—Cœnosarc mainly composed of a retiform hydrorhiza, which consists of anastomosing tubes, invested by a periderm; hydrocaulus rudimental (or absent?). Polypites claviform, with a single verticil of filiform tentacles surrounding the base of a conical metastome. *Gonosome*.—Gonophores adelocodonic, borne on the body of the polypite at the proximal side of the tentacles. Two species.

Genus 2. *Podocoryne*, Sars (in part). *Trophosome*.—Cœnosarc invested by a periderm, and composed of a creeping retiform hydrorhiza, with a rudimental hydrocaulus, consisting of very short, simple, tubular processes from the free surface of the hydrorhiza, and having the polypites developed from their extremities. Polypites, with a single verticil of filiform tentacula, placed round the base of a conical metastome. *Gonosome*.—Gonophores phanerocodonic, borne on the body of the polypite at the proximal side of the tentacles. Medusa, with a deep bell-shaped umbrella, a small four-lipped manubrium, four radiating canals, and eight marginal tentacles, with bulbous bases, but destitute of ocelli. Two species.

Genus 3. *Corynopsis*, Allman. *Trophosome*.—Hydrorhiza ramified and creeping; hydrocaulus rudimental or absent. Polypites claviform, with a single verticil of filiform tentacula surrounding the base of a conical metastome. *Gonosome*.—Gonophores phanerocodonic, borne on the body of the polypite at the proximal side of the tentacular verticil. Medusa at the time of liberation deep bell-shaped; manubrium not reaching the orifice of the bell, and having its mouth surrounded by four short tentacles; radiating canals four, each terminating distally in a bulb, from which are developed two tentacles, each with a distinct ocellus at its base. One species.

Genus 4. *Diplura*, Greene. *Trophosome*.—Polypite supported on the summit of a simple hydrocaulus, with a branched and creeping (?) hydrorhiza; periderm (?); tentacles filiform in a single verticil (?) near the distal extremity of the body. *Gonosome*.—Gonophores phanerocodonic, on simple peduncles, which arise in a verticil from the body of the polypite at the proximal side of the tentacles. Medusa deep bell-shaped, with moderate sized manubrium; radiating canals four, each terminating in a bulbous expansion at the point of intersection with the circular canal; from one of these marginal bulbs two long tentacles are developed; the rest of the margin is destitute of tentacles.

Family 3. *Hydractinidæ.*

Genus 1. *Hydractinia,* Von Beneden. *Trophosome.*—Cœnosarc forming a continuous expansion whose free surface is destitute of periderm, but whose deeper parts consist of an areolar mass of freely intercommunicating tubes, which are each invested by a distinct periderm, and are adnate to one another. Polypites claviform, developed at intervals from the free naked surface of the cœnosarc; tentacles filiform, approximated into a single verticil round the base of a very contractile and mutable metastome. *Gonosome.*—Sporosacs supported on gonoblastidia, which arise, like the polypites, from the naked free surface of the cœnosarc, are destitute of tentacles, and terminated by spherical clusters of thread cells. Two species.

Genus 2. *Rhizocline,* Allman. *Trophosome.*—Cœnosarc forming an adherent stratum, supported by a solid chitinous expansion. Polypites developed at intervals from the free surface of the cœnosarc; tentacles filiform, in a single verticil round the base of a conical metastome. *Gonosome.*—Gonophores phanerocodonic, sessile on the free surface of the cœnosarc; umbrella, at the time of liberation, deep bell-shaped; manubrium large, with a four-lipped mouth, but not extending beyond the margin of the umbrella; four radiating canals continued distally by four marginal tentacles with bulbous bases; three shorter tentacles, developed in each interradial space. One species.

Family 4. *Laridæ.*

Genus 1. *Lar,* Gosse. *Trophosome.*—Cœnosarc a creeping, filiform, and anastomosing hydrorhiza, on which sessile polypites are developed at intervals; periderm (?). Polypites fusiform, with two tentacula, situated at the base of a two-lipped metastome. *Gonosome* not known. One species.

Family 5. *Corynidæ.*

Genus 1. *Coryne,* Gaertner. *Trophosome.*—Cœnosarc consisting of a simple or branching hydrocaulus rooted by a creeping, filiform hydrorhiza, the whole invested by a chitinous periderm. Polypites developed from the summits of the hydrocaulus, clavate; tentacles capitate, scattered on the body of the polypite. *Gonosome.*—Gonophores adelocodonic, developed from the body of the polypite. Four or five species.

Genus 2. *Syncoryne,* Ehrenberg (in part).—*Trophosome.* Cœnosarc composed of a simple or branching hydrocaulus rooted by a creeping, filiform hydrorhiza, and the whole invested by a chitinous periderm. Polypites claviform, developed from the summits of the hydrocaulus; tentacles capitate, scattered upon the body of the polypite. *Gonosome.*—Gonophores phanerocodonic, developed upon the body of the polypite. Umbrella, at time of liberation, deep bell-shaped; manubrium moderately large, not reaching the mouth of the bell, destitute of oral tentacles; radiating canals four; marginal tentacles four, with bulbous bases, generally furnished with an ocellus. In some cases the gonophores, though phanerocodonic, never become free, and the marginal tentacles then remain in an imperfectly developed state. Nine species.

Genus 3. *Zanclea,* Gegenbaur. *Trophosome.*—Cœnosarc consisting of a simple or branching hydrocaulus, rooted by a filiform anastomosing hydrorhiza, the whole invested by a periderm. Polypites claviform, developed from the summits of the hydrocaulus; tentacles capitate, scattered over the body of the polypite. *Gonosome.*—Gonophores phanerocodonic, developed from the body of the polypite. Medusa, at the time of its liberation from the trophosome, nearly spherical; manubrium simple-mouthed, not reaching the margin of the umbrella; radiating canals four; marginal tentacles two, developed from the distal extremities of two opposite radiating canals; two intermediate bulbous dilatations at the intersections of the two other radiating canals with the circular canal; the tentacles commence with a large bulbous dilatation, destitute of distinct ocellus, and are for the remainder of their extent closely set along their external sides, with the pedunculated sacs filled with thread cells; from the bases of the tentacula and intermediate bulbs a cæcal claviform tube filled with thread-cells extends in the walls of the umbrella, near its external surface, and parallel to the corresponding radiating canal. One species.

Genus 4. *Corynitis,* M'Crady. *Trophosome.*—Polypites springing from an adherent base; tentacles capitate, scattered over the body of the polypite. *Gonosome.*—Gonophores phanerocodonic, borne upon the body of the polypite. Umbrella, deep bell-shaped, thick-walled, with clusters of thread-cells imbedded in its walls, and with the roof of its cavity rising in four over-arched spaces between the radiating canals; manubrium massive; radiating canals, four; marginal tentacles four, club-shaped, with basal bulbs, each furnished with an ocellus. One species.

Genus 5. *Candelabrum,* De Blainville. *Trophosome.*—Polypites clavate, springing from a tubular, adherent hydrorhiza, which is invested by a periderm; tentacles wart-like, scattered over the body of the polypite. *Gonosome.*—Gonophores adelocodonic (?), on gonoblastidia, which are clustered round the base of the polypite. Two species.

Family 6. *Pennaridæ.*

Genus 1. *Vorticlava,* Alder. *Trophosome.*—Polypites solitary, borne on the summit of a simple hydrocaulus, which is attached by a simple, conical (?) hydrorhiza; periderm a delicate transparent film investing the hydrocaulus and the hydrorhiza; tentacles in two verticils, those composing the proximal verticil long and filiform, those composing the distal verticil short and capitate. *Gonosome* unknown. Two species.

Genus 2. *Acharadria,* Strethill Wright. *Trophosome.*—Hydrocaulus branched, with a well-developed periderm; hydrorhiza (?). Polypites with two verticils of tentacula, those composing the proximal verticil, long and filiform, those composing the distal verticil, short and capitate. *Gonosome* unknown. One species.

Genus 3. *Heteractis,* Allman. *Trophosome.*—Polypite solitary, borne on the summit of a simple-rooted hydrocaulus; two verticils of tentacles, a proximal and a distal; the tentacles composing the proximal verticil long and annulated, those composing the distal verticil short and capitate. *Gonosome.*—Gonophores phanerocodonic, borne upon peduncles, which arise from the body of the polypite at the distal side of the proximal verticil of tentacles. Umbrella in the form of a shallow bell, with four radiating canals, one large marginal tentacle, and three rudimental ones. One species.

Genus 4. *Stauridium,* Dujardin. *Trophosome.*—Cœnosarc consisting of a branched or simple hydrocaulus arising from a creeping, filiform hydrorhiza, the whole invested in a periderm. Polypites borne on the summits of the hydrocaulus, clavate, with two verticils of tentacles, each verticil consisting of four tentacles arranged in a cross, the tentacles of the proximal verticil filiform, those of the distal verticil capitate. *Gonosome.*—Gonophores phanerocodonic, developed from the body of the polypite. Umbrella deep bell-shaped; manubrium not reaching the margin of the bell; mouth simple; radiating canals four; marginal tentacles four, nodulated with clusters of thread-cells, and with a distinct ocellus on the basal bulb.

Genus 5. *Cladonema,* Dujardin. *Trophosome* not distinguishable from that of *Stauridium.* *Gonosome.*—Gonophores phanerocodonic, developed from the body of the polypite. Umbrella deep bell-shaped; manubrium large, with simple mouth; radiating canals eight, each continued at the margin of the umbrella into a branching tentacle with a bulbous base provided with an ocellus. One species.

Genus 6. *Pennaria,* Goldfuss. *Trophosome.*—Cœnosarc composed of a symmetrically ramified hydrocaulus, rooted by a creeping, filiform hydrorhiza, the whole invested by a chitinous periderm. Polypites borne on the summits of the branches, oviform, with two sets of tentacles, a proximal set filiform, and arranged in a single verticil round the base of the polypite, and a distal set capitate, and scattered on the body of the polypite. *Gonosome.*—Gonophores phanerocodonic, developed between the proximal and distal sets of tentacles. Umbrella deeply ovate; manubrium large, but not passing beyond the orifice of the umbrella; radiating canals four; four rudimental, papilliform, marginal tentacles. Two species.

Genus 7. *Globiceps,* Ayres. *Trophosome.*—Cœnosarc rooted, symmetrically branched and invested by a chitinous periderm. Polypites claviform, with two sets of tentacles, a proximal set filiform and arranged in a single verticil round the base of the polypite, and a distal set capitate and arranged in one or more verticils, never scattered. *Gonosome.*—Gonophores phanerocodonic, developed between the proximal and distal sets of tentacles. Umbrella deeply ovate with large manubrium; four radiating canals and four rudimental, papilliform marginal tentacula. One species.

Family 7. *Clavatellidæ.*

Genus 1. *Clavatella,* Hincks. *Trophosome.*—Cœnosarc composed of a filiform branching hydrorhiza, with a hydrocaulus consisting of very short, simple stems, which arise from the free surface of the hydrorhiza, the whole invested by a periderm. Polypites developed from the summit of the hydrocaulus, and having a single verticil of capitate tentacula surrounding the base of a conical metastome. *Gonosome.*—Gonophores consisting of naked ambulatory medusæ, which are developed in clusters from the polypite near its proximal extremity. Umbrella not extended into a bell or disk fitted for natation; marginal tentacles six, bifurcated, the outer branch of the bifurcation terminated by a capitulum of large thread cells, the inner by a claviform enlargement which carries a suctorial disk of attachment; an ocellus at the root of each tentacle; no lithocysts. One species.

Family 8. *Eudendridæ.*

Genus 1. *Eudendrium*, Ehrenberg (in part). *Trophosome.*—Cœnosarc consisting of a well developed branching hydrocaulus, rooted by a creeping, filiform hydrorhiza, the whole invested by a chitinous periderm. Polypites developed from the summits of the branches, vasiform or oval, with the metastome contracted at its proximal and expanded at its distal extremity, so as to be more or less trumpet-shaped; tentacles filiform, in a single verticil, just below the metastome. *Gonosome.*—Gonophores adelocodonic, developed from the body of the polypite at the proximal side of the tentacles, or from the hydrocaulus; female sporosacs monothalamic; male sporosacs polythalamic. Eleven species.

Genus 2. *Atractylis*, Strethill Wright (in part). *Trophosome.*—Cœnosarc consisting of a hydrocaulus in the form of simple funnel-shaped stems, which are developed at intervals from a creeping filiform hydrorhiza, the whole invested by a chitinous periderm. Polypites emerging from the summits of the hydrocaulus, into which they are retractile, fusiform, with filiform tentacula placed in a single verticil round the base of a conical metastome. *Gonosome.*—Gonophores adelocodonic, carried on the sides of the hydrocaulus. One species.

Genus 3. *Bimeria*, Strethill Wright. *Trophosome* consisting of a branching rooted cœnosarc invested by a chitinous periderm. Polypites developed from the summits of the branches, vase-shaped, destitute of metastome, and having the tentacles in a single verticil round the margin of the distal end of the vase-shaped body. Periderm, body, mouth, and lower half of each of the tentacles, clothed in an opaque brown membrane. *Gonosome.*—Gonophores adelocodonic, developed from the cœnosarc. One species.

Genus 4. *Garveia.* Strethill Wright. *Trophosome.*—Cœnosarc invested by a periderm, and consisting of a branched hydrocaulus, which is rooted by a filiform hydrorhiza, and towards its base composed of aggregated tubes. Polypites fusiform, developed on the summits of the branches, and having the tentacles in a single verticil round the base of a long conical metastome. *Gonosome.*—Gonophores adelocodonic, borne on the summits of short branches which spring from the sides of the hydrocaulus. One species.

Genus 5. *Heterocordyle*, Allman. *Trophosome.*—Cœnosarc consisting of a simple or branched hydrocaulus, which arises from a creeping, filiform, and anastomosing hydrorhiza, the whole invested by a chitinous periderm. Polypites fusiform, with a single verticil of filiform tentacula round the base of a conical metastome. *Gonosome.*—Gonophores adelocodonic, borne by gonoblastidia, which are developed (solely ?) from the hydrorhiza; sporosac of the ordinary kind, destitute of tentacles and cilia, and incapable of locomotion. One species.

Genus 6. *Perigonimus*, Sars. *Trophosome.*—Cœnosarc invested by a periderm, and consisting of a branching or simple hydrocaulus rooted by a filiform hydrorhiza. Polypites borne on the summits of the hydrocaulus, fusiform, with a single verticil of filiform tentacula, which surround the base of a conical metastome. *Gonosome.*—Gonophores phanerocodonic, developed from the cœnosarc. Umbrella at the time of liberation deep bell-shaped, with a manubrium which is shorter than the height of the bell cavity, and has a mouth which is simple, or with four shallow lips; radiating canals, four; marginal tentacles, two or four, with bulbous bases, which are not furnished with distinct ocelli. Eight species.

Genus 7. *Bougainvillia*, Lesson. *Trophosome.*—Cœnosarc consisting of a branching hydrocaulus rooted by a filiform hydrorhiza, the whole invested by a periderm. Polypites developed from the summits of the branches, fusiform, with a conical metastome; tentacles filiform in a single verticil round the base of the metastome. *Gonosome.*—Gonophores phanerocodonic, developed from the cœnosarc. Medusa, at the time of liberation, with a deep bell-shaped umbrella; manubrium shorter than the height of the bell cavity, with four oral tentacles; radiating canals four, each terminating at its intersection with the circular canal, in a bulb, from which two tentacles are developed, each with an ocellus at its base. Three species.

Family 9. *Dicorynidæ.*

Genus 1. *Dicoryne*, Allman. *Trophosome.*—Cœnosarc consisting of a branched or simple hydrocaulus, which arises from a creeping, filiform, and anastomosing hydrorhiza, the whole invested by a periderm. Polypites fusiform, with a single verticil of tentacula surrounding the base of a conical metastome. *Gonosome.* — Gonophores adelocodonic, developed upon gonoblastidia, which are borne either upon the hydrocaulus or the hydrorhiza. Sporosacs natatory, ciliated over their whole surface, and having two filiform tentacula diverging from the proximal end. One species.

Family 10. *Tubulariadæ.*

Genus 1. *Tubularia*, Linnæus (in part). *Trophosome.* — Cœnosarc invested by a chitinous periderm, and consisting of a simple or branched hydrocaulus rooted by a filiform hydrorhiza. Polypites flask-shaped; tentacles filiform, in two verticils, those composing the proximal verticil longer than those composing the distal; distal verticil surrounding the base of a conical metastome. *Gonosome.* — Gonophores adelocodonic, developed upon racemiform peduncles, which spring from the body of the polypite between the proximal and distal verticil of tentacles. Twelve species.

Genus 2. *Ectopleura*, Agassiz. *Trophosome.*—Cœnosarc invested by a chitinous periderm, and consisting of a simple or branched hydrocaulus springing from a filiform (?) hydrorhiza. Polypites flask-shaped, with filiform tentacula arranged in two verticils, the proximal verticil composed of tentacles which are longer than those forming the distal verticil. *Gonosome.*—Gonophores phanerocodonic, on branched peduncles, which are borne upon the body of the polypite, between the proximal and distal verticils of tentacles. Medusa, at the time of liberation, with a nearly spherical umbrella; a manubrium with a simple mouth, and shorter than the height of the umbrella cavity; four radiating canals, and four marginal tentacles; no distinct ocelli; the umbrella furnished with eight prominent longitudinal ribs formed of linear series of thread cells. One species.

Genus 3. *Hybocodon*, Agassiz. *Trophosome.*—Cœnosarc invested by a chitinous periderm, and consisting of a simple (or branched ?) hydrocaulus rooted by a filiform hydrorhiza. Polypites flask-shaped, with the tentacles arranged in two sets, the proximal set long, and forming a single verticil, the distal short, and arranged in two verticils. *Gonosome.*—Gonophores phanerocodonic, springing directly from the body of the polypite, between the proximal and distal sets of tentacles. Medusa, at the time of liberation, with a deep bell-shaped umbrella, a moderate sized, simple-mouthed manubrium, four radiating canals, and with the distal extremity of one of the canals prolonged into a single marginal tentacle with a bulbous base, but without distinct ocellus. One species.

Genus 4. *Corymorpha.*—Sars (in part). *Trophosome.*—Polypite solitary, borne on the summit of a simple hydrocaulus, which terminates proximally in a conical hydrorhiza; both hydrocaulus and hydrorhiza invested by a very delicate, transparent, filmy periderm. Polypites flask-shaped, with two sets of filiform tentacles, a proximal and a distal, the proximal imperfectly contractile, longer and thicker than the distal, and arranged in a single verticil near the base of the polypite; the distal set very contractile, forming several closely-placed, alternate, more or less perfect verticils behind a conical metastome. *Gonosome.*—Gonophores phanerocodonic, borne on branched peduncles, which spring from the body of the polypite at the distal side of the proximal set of tentacles. The medusa, at the time of its liberation, has a deep-belled umbrella, a well-developed simple-mouthed manubrium, four radiating canals, and a single marginal tentacle; each of the radiating canals terminates, at its junction with the circular canal, in a bulbous expansion without distinct ocellus; one of these bulbs is larger than the other, and from this alone the solitary tentacle is developed. Two species.

Genus 5. *Amalthea*, O. Schmidt. *Trophosome.*—Polypites solitary, with two sets of filiform tentacles, a proximal and a distal,—the proximal set very long and placed in a single verticil; the distal set very short, numerous, and scattered. *Gonosome.*—Gonophores phanerocodonic, borne upon peduncles which arise between the proximal and distal sets of tentacles. Medusæ with a deep bell-shaped umbrella, four radiating canals, and four equal marginal tentacles with bulbous bases. Three species.

Genus 6. *Monocaulos*, Allman. *Trophosome.*—Polypite solitary, borne on the summit of a simple-rooted hydrocaulus; both hydrocaulus and hydrorhiza invested by a very delicate periderm; polypites flask-shaped, with two sets of filiform tentacles,—a proximal set longer and thicker, and arranged in a single verticil near the base of the polypite, and a distal set shorter and thinner, and scattered over a zone close to the summit of the polypite. *Gonosome.*—Gonophores adelocodonic, on simple or branched peduncles, which spring from the body of the polypite at the distal side of the longer tentacles. Two species.

Genus 7. *Nemopsis*, Agassiz. *Trophosome.*—Polypite free, conical, with two verticils of filiform tentacula, a proximal near the base, and a distal near the apex; periderm absent. *Gonosome.*—Gonophores phanerocodonic, on short simple peduncles which spring from the body of the polypite between the two verticils of tentacula. Umbrella deep bell-shaped; manubrium of moderate size, and furnished with four dichotomously branched oral tentacles; radiating canals four, each terminating in a marginal bulb, while from every marginal bulb a tuft of tentacles is given off, two of the tentacles in each tuft being clavate, and but slightly contractile, the rest filiform and very contractile, every tentacle carrying a distinct ocellus at its base. The generative elements are developed in four lobes, which spring from the base of the manubrium, and thence extend for some distance along the course of the radiating canals. One species.

Genus 8. *Acaulis*, Stimpson. *Trophosome.*—The entire trophosome consists of a solitary, free, subfusiform polypite, which at a later period becomes attached by its proximal extremity; tentacles of two kinds—one filiform, forming a single verticil near the proximal extremity, and subsequently disappearing; the other capitate and scattered on the body of the polypite towards its distal extremity; periderm absent. *Gonosome.*—Gonophores phanerocodonic, springing from the body of the polypite between the filiform and capitate tentacula. Form of the medusa unknown. One species.

ORDER II. CAMPANULARIA.

Family 1. *Campanulariadæ.*

Genus 1. *Campanularia*, Lamarck (in part). *Trophosome.*—Hydrocaulus simple or branching, rooted by a creeping filiform hydrorhiza; hydrothecæ bell-shaped, with an entire or serrated margin and destitute of an operculum; tentacles surrounding the base of a large very contractile metastome. *Gonosome.*—Gonangium seated either on the hydrorhiza or hydrocaulus, and containing phanerocodonic gonophores. Umbrella, at the time of liberation, deep bell-shaped; manubrium of moderate size, with the mouth provided with four shallow lips, or simple; radiating canals four; marginal tentacles four, with bulbous bases destitute of ocelli; lithocysts eight, two in each interradial space, and never developed upon the base of a tentacle; generative elements developed in special sporosacs, which are borne as buds on the radiating canals. As the medusa advances to maturity the marginal tentacles increase in number, and the oral lobes of the manubrium become more decided. Eleven species, of which seven are provisional.

Genus 2. *Obelia*, Péron and Lesueur. *Trophosome.*—Hydrocaulus branching, rooted by a creeping, filiform hydrorhiza; hydrothecæ bell-shaped, with an entire or serrated margin, and destitute of operculum; tentacula surrounding the base of a very contractile, conical clavate, or trumpet-shaped metastome. *Gonosome.*—Gonangia developed from the hydrocaulus, and containing phanerocodonic gonophores. Medusæ very flat, so as to approach the form of a disk, with a short four-lipped manubrium; radiating canals four; marginal tentacles numerous, with their roots prolonged in the form of short cæcal continuations into the walls of the umbrella; lithocysts two in each interradial space, each lithocyst placed upon the base of a tentacle at its inner side. The changes undergone by the medusa in its progress towards maturity consist chiefly in an increase in the number of marginal tentacles. Four species.

Genus 3. *Laomedea*, Lamouroux (in part). *Trophosome.*—Hydrocaulus simple or branched, rooted by a creeping filiform hydrorhiza; hydrothecæ bell-shaped, with the margin entire or serrated, but without an operculum; tentacular verticil surrounding the base of a very contractile conical or trumpet-shaped metastome. *Gonosome.*—Gonangium developed on the hydrorhiza or hydrocaulus, and containing adelocodonic gonophores, which never leave the cavity of the gonangium. Nine species.

Genus 4. *Hincksia*, Agassiz. *Trophosome.*—Hydrorhiza, a creeping network of filiform tubes, from which a short simple hydrocaulus is emitted at intervals; hydrothecæ bell-shaped, destitute of operculum. Polypites (?). *Gonosome.*—Gonangia borne on the hydrorhiza, and consisting of large, subcordate, pedunculated capsules, with a small terminal aperture, transversely ribbed on one side, smooth on the other.

Genus 5. *Gonothyræa*, Allman. *Trophosome.*—Hydrocaulus branching, rooted by a filiform hydrorhiza; hydrotheca well shaped, with entire or serrated margin, and destitute of operculum; tentacula surrounding the base of a large and very contractile metastome. *Gonosome.*—Gonophores adelocodonic. Sporosacs in the form of imperfect medusæ (meconidia), carrying round the rudimental codonostome a circle of filiform tentacula, and, when mature, supported on the summit of the gonangium, where they lie entirely external to its cavity. Two species.

Genus 6. *Trichydra*, Strethill Wright. *Trophosome.*—Hydrorhiza a branched and creeping thread, which sends off at intervals a rudimental hydrocaulus in the form of very short, tubular, cell-like processes, into which the polypites are very retractile. Polypites very slender and cylindrical, carrying a single verticil of filiform tentacula round the base of a short conical metastome. *Gonosome* unknown. One species.

Genus 7. *Calycella*, Hincks. *Trophosome.*—Hydrocaulus erect, and rooted by a filiform hydrorhiza, or creeping and adherent; hydrothecæ tubular or conical, and provided with an operculum, which is formed of converging lanceolate segments. Polypites cylindrical, with the tentacula verticil surrounding the base of a conical metastome. *Gonosome.*—Gonophores adelocodonic. Sporosacs of female ultimately delivering their contents into an acrocyst. Three species.

Genus 8. *Campanulina*, Van Beneden. *Trophosome.*—Hydrocaulus branching or simple, attached by a creeping filiform hydrorhiza; hydrothecæ with their margin continued by a delicate collapsible membrane, or else provided with a true operculum, formed by converging lanceolate segments. Polypites cylindrical; tentacula connected by a membranous web at their base. *Gonosome.*—Gonophores phanerocodonic. Medusa, at the time of liberation, deep bell-shaped, with moderate sized four-lipped manubrium; radiating canals four, each terminating distally in a non-ocellated bulb; marginal tentacles two, developed from two opposite bulbs (or four, every bulb then carrying a tentacle); lithocysts eight, two in each marginal space. Two species.

Family 2. *Æquoridæ.*

Genus 1. *Zygodactyla*, Brandt. *Trophosome.*—Hydrocaulus simple, or branched (?), rooted by a creeping filiform hydrorhiza; hydrothecæ with an operculum formed of converging lanceolate segments. Polypites cylindrical, with a verticil of filiform tentacula, connected at their base by a broad membranous web. *Gonosome.*—Gonophores phanerocodonic. Medusæ with a broad, shallow umbrella, and wide and short manubrium, whose lips are prolonged into numerous arm-like lobes; radiating canals very numerous, radial and interradial, each developed from a bulbous base; margin of umbrella with lithocysts; generative elements developed along the course of the radiating canals. One species.

Family 3. *Thaumantidæ.*

Genus 1. *Thaumantias*, Eschscholtz. *Trophosome.*—Hydrocaulus rooted by a creeping, filiform hydrorhiza; hydrothecæ destitute of an operculum. Polypites with the tentacular verticil surrounding the base of a trumpet-shaped metastome. *Gonosome.*—Gonophores phanerocodonic. Mature medusa with a hemispherical umbrella, and short manubrium with lobed mouth margin; radiating canals four; marginal tentacles numerous; lithocysts absent; generative sacs band-like along the course of the radiating canals. One species.

Family 4. *Leptoscyphidæ.*

Genus 1. *Leptoscyphus*, Allman. *Trophosome.*—Hydrocaulus simple or branching, attached by a creeping filiform hydrorhiza; hydrothecæ with an operculum composed of converging lanceolate segments. Polypites cylindrical when extended; tentacula surrounding the base of a conical metastome. *Gonosome.*—Gonophores phanerocodonic; umbrella, at the time of liberation, deep bell-shaped, or conical; manubrium pendent from a conical projection from the roof of the umbrella, of moderate size, with the mouth surrounded by four short capitate tentacula; radiating canals four, each terminating distally in a bulb, without evident ocellus, each bulb giving origin to a cluster of two or three tentacles; a single marginal tentacle with a bulbous base is also developed from the centre of each interradial space. One species.

Genus 2. *Lafoëa*, Lamouroux. *Trophosome.*—Hydrocaulus creeping and adherent, or erect and rooted by a filiform hydrorhiza; hydrothecæ sessile on the hydrocaulus, or pedunculated; tube destitute of an operculum. Polypites cylindrical, with the tentacular verticil surrounding the base of a spherico-conical metastome. *Gonosome.*—Gonophores phanerocodonic; medusæ deep bell-shaped, with short manubrium, four radiating canals, and four marginal tentacles with bulbous bases, destitute of ocelli; tentacles alternately long and short; lithocysts not present. Four species.

Family 5. *Lineolaridæ.*

Genus 1. *Lineolaria*, Hincks. *Trophosome.* — Hydrocaulus creeping and adherent, tube carrying the hydrothecæ from distance to distance along its length; hydrothecæ sessile on the hydrocaulus, tubular, with the orifice sub-triangular, and armed with an ear-like projection on each side. Polypites not known. *Gonosome.*—Gonangia large, oviform, and adherent, sessile on the creeping hydrocaulus. Gonophores not known. One species.

This is the proper place for an account of the distribution of the class, but our space will not permit of it. Many facts have been collected respecting the present, but a few only of the past, distribution. It might be considered impossible that such soft evanescent masses as jelly fishes could have left any record of their existence in ancient sedimentary deposits. The first steps towards their geological history have, however, been afforded us by the discovery of recognizable acalephan impressions on the oolitic lithographic slates of Eichstadt. Haeckel has distinguished four species, which he names—*Medusites deperditus*, *M. antiquus*, *Rhizostomites admirandus*, and *R. lithographicus*, for descriptions of which the reader is referred to the under-mentioned memoirs. *Palæocoryne* is a still older genus, of the order *Tubularia*, which has been found in the lower beds of the coal fields of west Scotland.

(Allman, *Report of the Thirty-third meeting of the British Association for the Advancement of Science*, 1864, p. 351-426; Louis Agassiz, *Contributions to the Natural History of the United States*, vols. iii. and iv; Reichert, *Reichert und Du Bois Reymond's Archiv.*, 1866, p. 638; Allman, *Philosophical Transactions*, 1853, p. 367-384; Greene, *Manual of the Cœlenterata;* Huxley, *Oceanic Hydrozoa;* Clarke, *Journal Boston Society of Natural History*, vii., p. 531-567, and *American Journal of Science*, Second Series, xxxv., p. 346; Allman, *Annals and Magazine of Natural History*, Third Series, xiii., p. 345-379; Haeckel, *Zeitschrift für Wissenschaftliche Zoologie*, xv., p. 504; and *Neues Jahrbuch für Mineralogie*, &c., for 1866, p. 257-292.)

HYPERODAPEDON, a reptilian genus, remarkable for being one of the earliest representative types of the order *Lacertia*, for representing at a period at least as far back as the triassic, a structure singularly close to that of the living *Sphenodon*, and for the interest which attaches to its true geological age and range. Although it does not strictly conform to the Lacertian order, yet the features in which it differs from the ideal type are anomalies therefrom, which are in part met with amongst living species of lizards.

The genus was originally founded in 1858 upon the fragments of an individual from the reptiliferous sandstone near Elgin. The bodies of the vertebræ are amphicoelian, or slightly concave at both ends, in which respect it is not accordant with Professor Owen's definition of Lacertia, where he makes the possession of procoelian vertebræ a distinctive point. But several genera of living lizards, such as the Geckos and *Sphenodon*, have amphicoelian vertebræ. The vertebræ have moderately well-developed neural arches and spines; but the transverse processes to which the apparently single-headed ribs were attached were rudimentary, consisting of low tubercles. The ribs had an expanded articular end, and a slightly double-curved outline. The skull was not less than seven inches in length, and tapered from a breadth of about five inches posteriorly to one inch at the end of the snout, which must have been comparatively slender. The extreme ends of the jaw bones appear to have had a structure rarely met with in reptiles. The terminal portion of the maxilla curved upward, and the premaxillary bone curved downwards like a beak, so that between the two there was a notch. Nothing is to be seen in the notch, but there are indications that a process from the lower jaw formerly fitted into it. It is probable that this process was a tooth, and that the premaxilla also terminated in one or more teeth. A similar arrangement occurs in the recent *Uromastix* and the extinct *Rhynchosaurus.* In *Uromastix* and most lizards, the premaxillaries are blended together into one bone; but in *Hyperodapedon* they are distinct, as is also the case in *Sphenodon.* The orbit was large, and the temporal fossa was probably bounded by two bony bars, of which the upper was found by the malar and the squamosal; there are no visible traces of the infra-temporal bar, but Professor Huxley believes that analogy renders its existence probable. Such an arch does occur in *Rhynchosaurus*, which is the genus most nearly allied to *Hyperodapedon*, so far as known.

There are indistinct traces of the bones of the scapular arch, the proportions of which indicate a small fore leg. Those of the pelvic arch and appendages are better preserved. The femur is a strong, straight bone, and with the tibia and fibula, of which partial impressions are to be detected, was fully capable of sustaining the body in progressing on dry land.

The most singular feature in *Hyperodapedon* is the arrangement of the dental apparatus. The palatine and maxillary bones are connected by lateral sutures; the outer edge of the former bears at least two rows of teeth, and the inner edge of the latter supports one row on a ridge, the suture occupying the depression or groove. The lower jaw has a single row of teeth on each side; but the teeth are so imbedded in the bone and so sharp that the margin of the mandible is more like a serrated knife edge. This knife edge, there is little doubt, worked in the groove of the upper jaw, so that the action of the teeth resembles that of a complicated pair of scissors. In order to make this description more intelligible, we will make a few extracts from Professor Huxley's recent paper on the subject:—"In the winter of 1866, however, the Rev. Dr. Gordon sent me several specimens, among which one (belonging to Mr. Grant, of Lossiemouth), though a very much mutilated fragment of a skull, presented part of the characteristic dentigerous bones of the palato-maxillary apparatus of *Hyperodapedon;* and my attention was at once forcibly drawn to the fact that the opposed faces of two of the rows of teeth were worn down by attrition against other teeth. These two rows of teeth were placed on opposite sides of a deep longitudinal groove, and the planes of the worn faces converged to the bottom of the groove. On looking at the original specimen, it became clear that this groove corresponded with the depression into which the oral edge of the mandible is received when the mouth is shut. The opposed faces of the palato-maxillary teeth had been worn flat by attrition against the opposite sides of the mandibular teeth, which work between them as a knife blade shuts into its handle; and it followed that the dentary margin of the mandible must be worn to an edge adapted to fit into the groove. So far as I know, no other fossil reptile possesses any such peculiarities; and thus this interesting fragment presented me with new means of distinguishing the teeth and jaws of *Hyperodapedon* from those of other *Reptilia*. . . . It is upon this part of the organisation of *Hyperodapedon* that Dr. Lloyd's specimens throw such important light. One of them, which is smaller and more perfect than the other, exhibits nearly the whole of the characteristically convex dentigerous margin, and excavated and outwardly inclined outer face of the palato-maxillary of *Hyperodapedon.* Its posterior margin is smooth, and rounded below, exhibiting the natural termination of this part of the bone. The inner surface is also quite smooth, and could not have united suturally with any other bone. The exterior end of the bone is broken off transversely; but probably very little of it is lost. As it is, it measures 1·5 inches in length, and the palatine surface has a width of 0·25 in. in front, and 0·55 in. behind. The section of the bone is trihedral, the outer face of the trihedron being somewhat concave, the inner convex from above downwards; the anterior half of the upper edge is thin and broken; the posterior half is a comparatively broad, longitudinally grooved, narrow [?] surface. Along the bottom of the groove lie three apertures, which are probably vascular foramina; and other such foramina lie on the inside and on the outside of the ridge into which the anterior half rises. One of the foramina on the inside is the commencement of a canal which traverses the base of the ridge longitudinally. The posterior half of the oral surface of the bone presents two faces, which are inclined towards one another at an obtuse angle; the wide valley which they include ends abruptly in a sharply cut, narrow groove. On the outside of the groove lies a single row of fifteen teeth anchylosed with the edge of the outer wall of the valley. The anterior eleven of these are worn down to a level with the bony substance of the jaw; the twelfth and thirteenth have their points ground away, while the fourteenth and fifteenth are entire and sharply pointed. The inner wall of the valley presents two parallel series of teeth, one on the middle, and one on the extreme inner edge. Traces of fourteen or fifteen can be discovered in each series. Those of the middle series are, all but the very hindmost, worn down to the surface of the bone, while of the inner series the four hindmost teeth are but little affected by wear. The teeth of the outer series are larger than those of the inner, the base of the largest being 0·15 in. in diameter; the middle teeth in each series are the largest, the anterior and posterior diminishing in size. The inner two series of teeth cannot be traced as far forward as the outer, the inner wall of the anterior half-inch of this valley being so thoroughly ground down that it is converted nearly into a plain. It is a curious circumstance that at the posterior part of the inner surface the apices of four teeth appear as if they were about to protrude on this face. It is quite clear that this remarkable wearing down of the palato-maxillary teeth can only be explained by their attrition against the teeth of the mandible, and the sharpness of the groove in the posterior half of the palatal surface clearly shows that these mandibular teeth were themselves sharpened to a sort of knife edge. Dr. Lloyd's second specimen is a fragment of a larger palato-maxillary bone of the same (left) side. It is, however, smaller relatively to the original size of the bone, as some of the anterior portion is broken away, and the posterior edge, though nearly preserved, is somewhat imperfect. The transverse diameter of the nearly entire posterior end is 0·8 in.; so that this bone is about half as large again as the foregoing, and belonged to an animal probably not more than half as large as the Elgin specimen. In this specimen the outer series of teeth is double posteriorly, two large conical teeth making their appearance on the outer side of the four which remain tolerably unworn. As before, there are two rows on the inner side of the groove, and anteriorly all the series of teeth are worn down to one flat surface with the bone which holds them. Mr. Whitaker's specimen from Devonshire is a right palato-maxillary bone of a *Hyperodapedon* of small size, probably less than that to which Dr. Lloyd's smaller specimen belonged. It is in an imperfect condition, but shows part of a single outer series of teeth and of two inner series, both completely worn down. The apices of four or five teeth project in two rows upon the posterior half of the inner face of this specimen. I purpose to give a full account of the Indian specimens elsewhere. At present I merely wish to observe that, for the most part, they belong to animals of a larger size than the Elgin specimen, but that I have not yet discovered any grounds for regarding them as specifically distinct. In the series sent by Dr. Oldham there is a fragment of a ramus of a mandible, which shows the scissor-edge character of the dentary margin extremely well."

It is remarkable that while *Hyperodapedon* differs from all fossil reptiles in its peculiar dentition, it agrees in that respect with the recent *Sphenodon*, which is the only one amongst recent forms which possesses this character.

Although the various fragments belong to individuals of different sizes, there is no certain indication that they belong to more than one species. This point, however, is not certain; so that the specific name *H. Gordoni* should be applied more especially to the Scotch specimens, since it was first given to them. The Warwickshire specimens are from the sandstone at Coton End, which, there is little doubt, belongs to the triassic series, and in all probability to the highest part of it, or the Keuper. The jaws from Devonshire may be confidently assigned to a post-carboniferous date, and there is much reason to believe they also belong to the newest part of the triassic group or the Keuper. The Indian specimens may be triassic, judging from the reptilian fauna associated with them, and the stratigraphical position of the beds in which they were found; but the evidence does not preclude the supposition that they may be older. The greatest doubt hangs about the fragments from the Elginshire reptiliferous sandstone. In this part of Scotland the old red sandstone group predominates, and this sandstone seems to form part of the series, as it conforms with the underlying strata in strike and dip. On this ground the sandstone with its organic remains is regarded by some as belonging to the old red sandstone period. If this be the case, it must be admitted, supposing the determination of the fossils be correct, that the same genus of reptiles, and it may be the same species, lasted from Devonian to triassic times, and this would be an argument in favour of the possibility of the Indian specimens being pre-triassic. But there are a few considerations which ought to prevent us from urging too confidently that the Scotch specimens are really of such extreme antiquity. The old red sandstone beds of Elginshire appear to belong to the highest part of the series as represented on other areas. At a lower level than the reptiliferous sandstone there are whitish sandstones with remains of fishes supposed to be characteristic of the highest old red sandstone strata. In more southern counties the equivalent zone is represented at Dura Den and other places, where it is immediately followed by the carboniferous group. In Elginshire the next overlying strata are pebble beds and conglomerates, and upon these rest the reptiliferous sandstone. The equivalents of these beds have nowhere been discovered as forming a part of the old red sandstone which is manifestly below the coal series; and in Elginshire the coal group is unrepresented, neither occurring beneath the reptiliferous beds nor above them. Pebble beds and conglomerates indicate a transgressive condition of the strata, and generally imply a lapse of time of considerable, but uncertain, duration. These sandstones, then, have not been correlated with any recognised portion of the old red sandstone series, and if correlative with any, such beds probably occupy a stratigraphical position intermediate between the Dura Den sandstone and the lower carboniferous of Fifeshire. Their isolation and the occurrence of the conglomerates leave room for suspecting they may be much newer than any part of the old red sandstone. In this condition of matters the student can accept one of two alternatives, and decide for himself whether it be more probable that beds of triassic date should lie conformably upon others belonging to the old red sandstone period, or that the same species, at any rate the same genus, should have lived from the latest Devonian on to the latest triassic. For our own part, we incline to accept the former alternative, and to regard *Hyperodapedon*, for the present, as triassic. Palæontologically, *Hyperodapedon* appears to belong to the triassic period, for its nearest ally is of that age; but this ally does not occur in the Elgin sandstone, and the reptiles which do there occur, have no more independent claims to be considered mesozoic than palæozoic. As this line of argument affords some presumptive testimony in favour of the Devonian age of the Scotch *Hyperodapedon*, we will allow Professor Huxley to follow it up in the following paragraphs:—"These facts leave no possible doubt, as it seems to me, that *Hyperodapedon* is a reptile of triassic age; but whether it is of exclusively triassic age or not, and therefore whether it is or is not competent to serve as a mark of the triassic age of the deposit in which it occurs, is quite another matter, and one respecting which it behoves us to speak very cautiously. Crocodiles, with the same vertebral character as those which now live, and not known to be distinct even from the modern restricted genus *Crocodilus*, lived at the epoch of the greensand, or, in other words, are common to two of the great divisions of geological time. The like is true of the teleostean fish *Beryx*. Moreover, it has been seen that *Hyperodapedon* is nearly allied to the living lizard *Sphenodon*—as nearly, I am inclined to think, as to its triassic congener *Rynchosaurus*. And if this form has persisted with so little modification from the trias till now, why may it not have inhabited the dry land of the Permian, of the carboniferous, or of the Devonian epoch? In discussing the question of the age of the Elgin sandstones in years gone by, reflections of this nature led me always to admit the possibility that these problematical beds might be of Devonian age; for *Hyperodapedon*, *Stagonolepis*, and *Telerpeton*, though clearly allied to triassic and mesozoic genera, were distinct from them, and had no stronger affinities with mesozoic *Reptilia* than the *Proterosauria* have (which yet are palæozoic and not mesozoic), or than some of the labyrinthodonts of the coal (*e. g. Anthracosaurus*) have with those of the trias. Even now that *Hyperodapedon* is distinctly determined to be a triassic genus, the possibility that it may hereafter be discovered in Permian, carboniferous, or even older rocks, remains an open question in my mind. Considerations of this kind should have their just weight when we attempt to form a judgment respecting the reptiliferous strata of the Karoo in South Africa and of Maledi and elsewhere in India. In India *Hyperodapedon* occurs, associated with Labyrinthodonts, with Thecodont reptiles (some of which have crocodilian characters), and with Dicynodonts. In South Africa *Hyperodapedon* has not been discovered; but Labyrinthodont and Thecodont *Reptilia* (some of them crocodiliform) have been found, and, associated with them, abundant Dicynodonts. In England and Scotland *Hyperodapedon* is found with Labyrinthodonts and Thecodont *Reptilia* of such distinctly crocodiliform type as *Stagonolepis*, but no *Dicynodon* has been found. In Wurtemburg, Labyrinthodonts and Thecodont *Reptilia*, some of them, like *Belodon*, eminently crocodilian, are associated together, probably with *Dinosauria;* but neither *Hyperodapedon* nor *Dicynodon* have yet been discovered. All these four faunæ are connected by reptilian genera which are respectively common to two of them: thus the British and Indian by *Hyperodapedon;* the Indian and the African by *Dicynodon;* the British and the German by *Labyrinthodon* (which, according to Von Meyer, occurs in Germany). The Labyrinthodonts and crocodiliform reptiles are common to all four. As the age of the beds in question is determined stratigraphically in Britain and in Germany to be triassic, it may seem over-refinement to hesitate in declaring the African and Indian formations to belong to the same period; but I confess the arguments I have mentioned lead me to greatly prefer some more general term, which should indicate a wider chronological range for the duration of the terrestrial fauna in question." If *Hyperodapedon* be of terrestrial habits, as the Labyrinthodonts assuredly were, the question of the age of *Hyperodapedon* manifestly has an important bearing in connection with the distribution of land; for wherever its remains occur there old land was not far distant. The near alliance of *Hyperodapedon* with *Sphenodon* would imply that a wave of land surface had passed from Great Britain to New Zealand in the interval between the establishment of the two genera, and along this area, whatever direction it may have taken, we may expect to find jaw-bones of the type common to these genera, and of every age from the Devonian, or more probably triassic, up to the recent period.

(Harkness, *Quar. Jour. Geo. Soc.* xx. p. 435; Huxley, *Quar. Jour. Geol. Soc.* xxv. p. 138; Whitaker, *ibid.* p. 152.)

HYPNUM. The principal genus of an order of pleurocarpous mosses, or that division in which the prevalent arrangement of the fruit is on the sides, not at the end, of branches. This order, named *Hypnei*, consists of plants with nodding capsules, long pedicles, and cylindrical stems. In *Hypnum* the upper margin of the little urn which contains the spores is double; that is, it is edged by two circlets of sharp equidistant teeth, each circlet comprising sixteen teeth. The space between the two circlets consists of a membrane which supports sixteen keeled, or frequently perforate, processes, which alternate in position with the outer teeth. Between the processes are a few cilia, by which character, as well as by its nodding capsule, it may be distinguished from *Leskea*. It differs from *Isothecium* in the capsule being curved or irregular in outline, not straight and symmetrical. The species are distributed nearly all over the world, and are very abundant in the British Isles, where they form dense matty coverings in consequence of the stems being imbricated and creeping in all directions over their basis of support. Nearly a hundred species are indigenous to this country. (Lindley and Moore, *Treasury of Botany*).

I

INFUSORIA. Formerly this term was used to denote a very heterogeneous assemblage of organisms which were associated together mainly on the ground that they were of very minute size, and were abundantly developed wherever decaying organic matter was associated with water. It included such groups as the *Desmideæ* and the *Diatomaceæ*, which are now generally recognised as plants; also the *Foraminiferæ* and *Polycystinæ*, which are regarded as groups distinct from the *Infusoria* in structure. Hence it will be seen that a large proportion of the article INFUSORIA in the Cyclopædia deals with organisms that are now excluded from the group of *Infusoria* proper. Most of the recent additions to our knowledge of the *Infusoria* are due to the researches of Lieberkühn, Stein, Carter, Balbiani, Gegenbauer, Lachmann, Claparède, Engelmann, and others.

On referring to the past history of this department of science it will be seen that its present state has only been attained by the establishment and demolition of a series of false hypotheses, which appear to be nearer the truth the more recent they are. This history forms a good illustration to the law laid down by Dr. Whewell in his History of the Inductive Sciences that every natural science passes through certain stages. First knowledge is entirely devoid of system or order; then follows a time of ill-assorted learning; definite characters become established, followed by systems which are at first based on artificial, and afterwards on natural methods, in which physiological data gradually acquire more and more importance. Thus we find Trembley and Gleichen patiently accumulating facts without attempting any classification. O. F. Mueller was the first to make such an attempt, which was soon followed by others, such as those by Lamarck and Bory de St. Vincent. Ehrenberg's system was the first that arranged the *Infusoria* into anything like order, but unfortunately the natural method was not adopted by him. Thus, for example, one of the principal characters on which many of his divisions rest is the presence or absence of a lorica, or protective sheath. The family *Vorticellina* of Ehrenberg is characterised by having no lorica, and the family *Ophrydina* is distinguished from it by possessing a lorica. He placed the genus *Stentor* in his *Vorticellina*, but although usually *Stentors* are non-loricated, yet they do sometimes secrete a gelatinous sheath, so that they belong at one time to the *Vorticellinæ*, at another to the *Ophrydinæ*. But the principal error of his system was the idea that a large proportion of the *Infusoria* were endowed with a complicated digestive apparatus, viz., a mouth, œsophagus, several stomachs, and an intestine. This hypothesis was opposed by many persons, and amongst others Dujardin, who maintained that these creatures were almost entirely wanting in organisation, and consisted of a homogeneous gelatinous substance which he termed *sarcode*. At first he denied the existence of a mouth, but subsequently he admitted its existence in some of the higher groups. Dujardin's theory was widely accepted, and found one of its chief supporters in Perty, in his work 'Zur Kenntniss der Kleinsten Lebensformen,' 1852. He agreed with Dujardin in denying the existence of an outer skin in most of the ciliated *Infusoria*, but differed from him in admitting that they possessed a ciliated œsophagus. Meyer, Siebold, Kölliker, and others have maintained that each infusorium is a simple cell filled with a gelatinous substance. Although this view is undoubtedly erroneous, yet the supporters of it have contributed greatly to our knowledge of the *Infusoria*. In 1852 Perty argued that these beings could not be compared to one cell, but rather to an aggregation of imperfectly developed cells, and that their degree of organisation was such that there could scarcely be said to be any differentiation of tissue or organs. It is mainly owing to the labours of the naturalists mentioned at the commencement of this article that the unicellular, sarcodous, and polygastric doctrines as propounded by Meyen, Dujardin, and Ehrenberg, are now only of historical interest.

In order to gain some idea of what an infusorium is, we will give a general outline of the structure of the most highly organized group, viz., the *Vorticellinæ*. It is mainly based on the researches of Lachmann and Stein. In this group, then, the animal generally consists of a cup-shaped body supported upon a slender stalk or pedicle by which it is attached to some stone or weed. The walls of the cup-shaped body are composed of a firm gelatinous and apparently structureless substance, to which the terms *parenchyma*, *diaphane*, and *cortical layer* have been applied by various writers. Above and surrounding the *diaphane* is a thin membrane or *cuticle* (*pellicula* of Carter), while the general cavity of the body is occupied by a viscid fluid substance (*sarcode* of Carter). The upper margin of the body is thickened and forms a raised edge which has been called the *peristome*. Upon the inner side of this peristome rests the base of a conical body the apex of which penetrates into the interior of the body. This body is known as the *rotatory* or *vibratile organ*, from its being the seat of the cilia, whereby a rotatory current in the water is created. Its base is called the *disk*, and its tapering portion the *peduncle;* the latter does not terminate in a point, but in a truncated end, the edge of which is reflected so as to impinge against the periphery of the body, thereby converting the space between the rotatory organ and the body-wall into a deep circular trench. The peduncle is endowed with the power of contraction and extension, so that the disk can be raised above the upper level of the body-wall or depressed below it. The cuticle already mentioned not only invests the outer surface of the body, but also extends over the peristome, along both sides of the trench and over the disk. The cilia are confined to the vibratile organ and are never inserted on the peristome; they are also arranged in a particular way. According to Lachmann and Claparède they form a two-rowed spiral, which commences at a certain point on the edge of the disk along which it continues until it has nearly completed a circle. It then gradually descends on the peduncle until a depression, or *vestibulum*, in the circular trench is reached. The number of turns made by the spiral varies with the species; in some it is rather less than two, in others it is as much as three or three and a half. The cilia are continued through the vestibulum and onwards to the end of the rudimentary alimentary canal. In this latter portion of the body the cilia act differently from, and independently of, those on the rotatory organ, as will be noticed presently; but before doing so a few words must be said about the vestibulum. This, it will be noticed, is placed at the bottom of the trench and in a line with the spiral of cilia. It was formerly regarded as the mouth; but it is a concavity at the bottom of which are two apertures, one of which is the mouth, or the entrance to the alimentary canal, and the other, close by, is the anal aperture, This pit is characteristic of the *Vorticellina* and the *Opercularia*. The mouth is always open, and leads into a canal or œsophagus, which is freely suspended within the general cavity of the body, and terminates in an enlarged portion forming a kind of pharynx. When the creature is in activity the disk is extended so that the water can readily enter into the circular trench. Each cilium on the rotatory organ has a backward and forward lashing action which promotes a constant current of water which is compelled to follow the course of the spiral, and consequently to strike upon the vestibulum. The stream does not enter the mouth, but is driven across it and the anal aperture, along a gradually shallowing portion of the trench, whereby it is conducted over the peristome into the surrounding water. The food of the creature usually consists of the minute particles of animal and vegetable matter contained in the current of water. The rejection or selection of the particles apparently depends upon the action of the cilia in the œsophagus, and it is not improbable that the setæ or non-vibratile bristles in the vestibulum may co-operate for the same purpose, since Lachmann has noticed that the coarse particles which sometimes lodge opposite the mouth are removed by them. According to many authorities there is a long stout bent bristle which springs from the space between the anus and the mouth, but Professor Clarke has shown that it is an optical illusion. (A. N. H. 3rd Ser., xvii., p. 401). The finer particles which are drawn into the mouth rush along the œsophagus, and are confined for a short time in the pharynx. Here they are subjected to a sort of rolling action along with the water that has entered until they have become aggregated into a bolus. This bolus is gradually pushed through the aperture of the pharynx, and is ultimately discharged into the interior of the body. In this form it is known as the *digestive globule*. A succession of similar globules are constantly being formed, but the amount of food they contain varies greatly. In some cases they have none. The whole of the interior of the body is filled with a thick mucus-like fluid, which is always slowly but constantly circulating. When the digestive globule is discharged from the pharynx it cleaves this mucus, and gives rise to a clear streak with two well defined boundary lines, which appears to have been mistaken by Ehrenberg for an intestine, and by other observers as a tube or special canal. The globule soon loses its acquired motion and takes part in that of the fluid by which it is surrounded. It circulates without following any definite course until its contents have been digested, which may occupy one or more turns. The waste products ultimately arrive in the vicinity of the anal aperture, which opens and discharges them into the vestibulum. Occasionally particles of food are not inclosed in a globule, and these penetrate into every corner of the interior. Thus it would seem that the digestive system of the highest *Infusoria* does not differ greatly from that of the *Actinia* as far as the general plan is concerned, although there is doubtless a marked difference in the degree of complexity. Indeed we shall find there are several other close analogies between the highest of the *Protozoa* and some of the simpler members of the more highly organized subkingdom of the *Cœlenterata*.

When a *Vorticella* is alarmed a remarkable change in its form takes place. The peduncle contracts, and brings the disk of the rotatory organ close upon the inner edge of the peristome, thus shutting in the circular trench. The action of the cilia ceases, while the peristome contracts like a sphincter muscle, and forms a protective covering over the disk. This is frequently accompanied by a sudden and powerful contraction of the stalk or pedicle, which contraction is not so apparent as the effect it produces of coiling up the stalk, and thereby lowering the body out of danger. There is no doubt about the contractility, but whether it is or is not due to muscular action is undecided. An elaborate paper by M. Czermak ('Zeits. für wissensch. Zool.' iv. p. 438), contains much evidence in favour of the presence of a muscle in the pedicle of *Vorticella*. Previous to his researches this part was generally considered to consist of a central filament (which Ehrenberg called a muscle), surrounded by cortical substance. Czermak has distinguished a third element, which he describes as a granular layer situated between the two parts already mentioned. This structure has been found to exist in all the stalked *Vorticella*; but the granular layer is sometimes difficult to detect: it is most highly developed in *Carchesium polypinum* and *C. spectabile*. Czermak shows that the contractile power resides only in this central filament, and explains the close relationship that exists between the anatomical structure of the pedicle and its helical form when contracted. The central filament and the granular layer are closely adherent to each other; and the granular layer fits closely to the cortical substance, so that any movement made by the filament must be shared by the pedicle as a whole. The base of the pedicle is composed entirely of the cortical substance, and it is by this alone the *Vorticella* adheres to foreign bodies. The filament and granular layer are attached to the inner surface of this basal part. The central filament or muscle, for such it very probably is, is continued upwards, and forms a conical membrane in the lower part of the parenchyma; this part of the body may frequently be seen to contract. Ehrenberg stated that the pedicle muscle is striated transversely, an observation which has also been made by Leydig; but other observers have been unable to confirm this observation. In *Zoothamnium alternans* the muscle is composed of longitudinal fibrillæ.

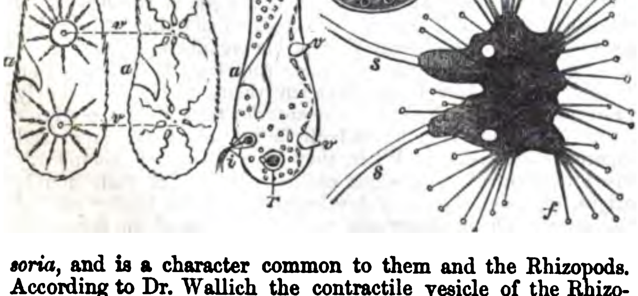
There are several other parts of which no mention has yet been made. In the parenchyma, and generally at the fore end of the body, close to the mouth, there is a *contractile vesicle*, or bladder-like body, which is constantly pulsating with a slow yet steady movement. Its function is doubtful, but it is believed to be in communication with a series of minute vessels, and with them acts as a rudimentary excretory organ, according to Carter; while Siebold, Wiegmann, and Lachmann, consider it to be a blood vascular system. There is another body which has also given rise to much discussion. In *Vorticella* it is in the form of a long riband, attached to the inner side of the parenchyma. It is known as the *nucleus*, but its function has not quite been made out; what little there is known about it will be mentioned further on, a remark which also applies to the various roundish bodies found in the sarcode, and known as the *moleculæ*, *granules*, *spherical cells*, *ovules*, and *spermatozoids*. All these parts are supposed to be more or less connected with the process of reproduction.

In the highest group of the *Infusoria*, it is evident that the individuals are composed of a greater number of parts than the *Rhizopods*, and that each of these parts has its own especial function to perform. As in the sponges, we have a current created by cilia, which current is directed by a particular conformation of parts into the cavity of the body; and after digestion the excreta are discharged by a special channel. It is possible that the process of digestion is effected in a similar way in both cases. But in the *Infusoria* the stomachal cavity is more decidedly isolated, and set apart for digestive purposes. Besides these organs for alimentation, they possess others for contraction, locomotion, reproduction, and probably excretion; so that instead of being unicellular, sarcodous, or polygastric animals, they are multicellular, many-tissued, and unigastric. This single stomach is conterminous with the general cavity of the body. These remarks are generally applicable to all the *Infusoria*.

The integumental appendages of the *Infusoria* vary considerably in size and shape, and would appear to be useful aids for classifying them into groups taken in conjunction with other characters. In the lowest group a simple filament or *flagellum* only is present, and is used generally as an organ of locomotion. It moves rapidly round an imaginary cone, and not backwards and forwards in the same plane like the cilia. In the next group cilia are present along with the flagellum. The flagella are of different kinds. Generally they consist of long, supple filaments, which can be readily moved in any direction, but sometimes they are filaments endowed with but slight powers of movement. They appear to differ greatly from the other kind, since they are capable of being attached to foreign objects, and contracting with powerful jerks, as in the pedicle of the *Vorticella*. They are usually associated with one or more of the ordinary kind placed in the anterior part of the animal. The cilia are present in most *Infusoria;* sometimes they are distributed over the whole of the body, as in *Stentor*, and sometimes they are confined to particular parts, as in *Vorticella*. Besides these we find stiff bristles (*setæ* and *styli*) and hooks (*uncini*), which are generally used for crawling over weeds, &c. Their mode of distribution in the various groups will be seen by reference to the classification given further on. We may also mention here the long processes of *Acineta*, and the fusiform bodies of *Bursaria* and a few other genera, although they are perfectly distinct from the cilia and bristles. The former are long hollow tubes, terminating in suckers, and are applied to the body of the prey that may be caught for the purpose of sucking out its contents. This remarkable power of suction removes much of the mystery with which these creatures have long been enveloped, and has been considered a sufficient characteristic for separating them, as a separate family, by MM. Claparède and Lachmann. The latter are of a peculiar spindle shape, and imbedded in the substance of the creature. They are thickly distributed over the whole body; each cell contains a slender resilient pointed thread, which can be emitted on irritation. In this respect they closely resemble the thread cells or urticating organs of the *Actinia*, *Hydra*, &c.; at present they appear to be analogous rather than homologous bodies.

The digestive apparatus of *Infusoria* presents some points of difference, which must not be entirely overlooked. In *Vorticella*, as we have seen, the mouth is situated in a cavity at the bottom of a trench, and leads into an œsophagus, which hangs freely in the cavity of the body, and terminates in an enlarged expansion or pharynx; this last feature is not possessed by most of the other genera. In most cases the form of the body cavity depends upon the external shape; but in *Trachelius* and *Loxodes* it assumes a peculiar ramified outline.

Nearly all the *Infusoria* are believed to have a mouth, although amongst many of the lower and smaller forms, such as the monads, &c., no satisfactory evidence of its existence has been obtained. All those which have cilia, either in their immature or mature state, are known to have a mouth, and in most cases they also have a second or anal aperture. In some genera, as in *Vorticella*, both apertures are situated at the bottom of the same cavity; in others, as in *Leucophrys*, they are placed at opposite extremities of the body; in a third group, the mouth is situated ventrally, and the anal aperture dorsally, as in *Chilodon* for example; and in a fourth group, which may be exemplified by *Paramecium*, both the anal and oral apertures, *a*, *i*, *fig.* 3, are placed on the ventral side. These characters form the basis of the classification of these creatures proposed by the late Professor Bronn of Heidelberg. Generally speaking the parts in the neighbourhood of the mouth are ciliated, but in *Chilodon* and *Nassula* the œsophagus is not ciliated. In these genera, however, it is provided with a number of stiff bristle-like bodies which are arranged in the form of a cone. The *Acineta* and its allies have no mouth when adult, their food being obtained by means of suckers.



In alluding to the *contractile vesicle* (*vesicula* of Carter), it was mentioned that the observers who had paid most attention to the subject have arrived at different conclusions respecting its function. This organ forms a strongly marked feature in the *Infusoria*, and is a character common to them and the Rhizopods. According to Dr. Wallich the contractile vesicle of the Rhizopods is essentially different from that of the *Infusoria;* since in the latter it possesses a true bounding membrane or wall, while in the former there is no such membrane. This point of distinction is, however, not sufficiently well established to be regarded as indisputable. It is found in nearly all *Infusoria*, and is not wanting even in such forms as *Euglena*, *Dinobryon*, *Chilomonas*, and *Cryptomonas*, although in them its activity is very slight. It is best seen in *Paramecium*, *Bursaria*, and *Vorticella*. The appearances presented by it at different stages of its action in *Paramecium* are represented in *v*, *figs.* 1, 2, 3. When the vesicle has expanded to its largest dimensions it is filled with a colourless fluid, and is apparently unconnected with any vessels. As soon as the systole or contraction commences, a number of canals, arranged in a star-like form, become visible as fine streaks: as the systole proceeds the streaks are converted into lines of globular or pyriform swellings, having the tapered ends pointing towards the vesicle; at the termination of the systole the fusiformly expanded vessels only are seen. With the commencement of the expansion or diastole the vesicle reappears, and when it has acquired half its full diameter we get the appearance represented in *fig.* 1, in which it will be noticed the tapered ends are directed away from the vesicle. At the end of the diastole the fully expanded vesicle again appears surrounded by almost invisible lines. On these points most observers are agreed, but they are not so unanimous as to where the fluid goes when it is discharged from the vesicle. According to Carter it passes from the vesicle, and through the sinuses, to special apertures communicating with the external water. He states that just before death these sinuses sometimes run into continuous hyaline lines, and may not only be seen extending in a radiated vascular form across the animalcule, but even branching out round the position of the vesicula, which having now become permanently contracted has thus poured back the contents which render them visible (*fig.* 2). They enter the lower or inner part of the organ, and at this point, therefore, are pushed inward as the vesicula becomes distended (*fig.* 3). Under the same circumstances also, when the vesicula is slowly dilating and contracting, it may be seen to be attached to small papillæ on the surface about twice the diameter of those which surmount the trichocysts, and through which it probably empties itself (*v*, *v*, *fig.* 3). If this be so, it might be inferred that the fluid is of an excretory nature, and that, like all such fluids, its accumulation is gradual; but such an inference does not apply in this case, since the vessels connected with the vesicula fill immediately after the systole. This difficulty would be removed by supposing that at the moment of contraction the valves of the vessels are shut so as to pour back the fluid in them; a supposition which cannot be considered valid as long as the existence of valves remains undemonstrated. Another objection is, that no current can be seen flowing from the papillæ. This is admitted by Carter, but he says it is because the drop of water ejected is colourless, and not because there is no current. Lieberkühn has also examined this system of vessels in *Bursaria*, but he explains the appearances in a different way. When an individual belonging to this genus is examined with a power of 300 diameters some light streaks are seen near the surface which converge in curves upon the contractile vesicle from all parts of the body. Each streak is an extremely delicate but perfectly distinct canal terminating in the vesicle; its wall and its contents are readily distinguished by their different refractive power. When one of these canals is traced from the orifice it ramifies at a short distance, which ramification may occasionally be traced to the extremity of the body; farther on another branch is given off, and still farther others may be detected. The canals are best seen when the nucleus or contractile vesicle is nearest the eye of the observer, as they then appear as dark lines on a bright background. In *Bursaria flava* about thirty canals open into the vesicula. Sometimes two vesicles and two systems of canals are met with in the same individual, as in the case of *Paramecium* (*fig.* 1), *Bursaria*, and other genera. The one system of canals appears to be unconnected with the other, although the fine extremities are distributed over the same area. *Bursaria* exhibits the phenomenon of pear-shaped bodies, which shape Lieberkühn attributes to the flow of liquid into the canals from the contractile vesicle. The same observer admits that there is an orifice near the posterior vesicle in *Bursaria*, but this he states, is the anal orifice of Ehrenberg, and does not communicate with the vesicle. He has frequently seen the remains of food discharged from this aperture. The short canal which issues from the vesicle in *Paramecium aurelia*, and appears to pierce the integument is, according to Lieberkühn, an optical illusion so far as the aperture is concerned. He asserts that it runs into the integument, and turns round without piercing it. The fluid, he thinks, originates at the remote extremities of the vessels, and then flows through them to the vesicle; the whole distance being traversed during a single diastole. Where the fluid goes to he is unable to say, but he mentions a fact which appears to throw some light on the question. As soon as the posterior vesicle of *Bursaria vorticella* has contracted, two long narrow cavities become visible at the margin of the animalcule, apparently from being filled with a transparent fluid. They extend from the vesicle to the vicinity of the mouth, and terminate in a globular enlargement. They gradually contract, and vanish, while the fluid disappears; but where it goes is not known. Lachmann confirms the existence of these long, narrow canals, but in many of the *Vorticellæ* there appears to be but one, not two. From this canal a smaller one branches off to the upper wall of the *vestibulum*, and then crosses to the other side. It hangs down like a short curtain into the vestibulum, and when the vesicle contracts it enlarges. From these facts it may be concluded that many of the *Infusoria* possess a vascular system, but whether it is a closed or an open one, and whether it conveys an excretory or a nutritive fluid is yet to be established.

The *Infusoria* propagate themselves in three ways, viz., by fission, gemmation, and by internal embryos. The first method appears to be very general, if not universal, while gemmation has, as yet, been seen only in the *Vorticellidæ*, *Acinetinæ*, and one or two genera in other families. The method by internal embryos has been met with in a great many families, as, for example, in the *Vorticellidæ*, *Acinetinæ*, *Trachelidæ*, *Opalinæ*, *Bursaridæ*, and even in a Rhizopod.

In most of the *Infusoria* multiplication is effected by means of repeated division and subdivision, and by the development of internal embryos; but there are some in which the first method only has as yet been seen; indeed, multiplication by fissiparity may be considered as a prominent characteristic of the class. The individual may divide either in a longitudinal, a transverse, or an oblique direction. Generally one of these directions prevails in the same species, but occasionally fission in two directions is met with in the above-mentioned limits. Thus, for example, longitudinal division is most general in *Chilomonas*, *Cryptomonas*, *Chlorogonium*, and *Polytonia*. In the former two each individual divides into two parts only, but in the latter two genera each individual gives rise to four or eight, or even thirty-two zooids. As very few of the *Infusoria* are strictly bilateral, the two zooids, in the case of simple fission, are usually unequal in size, and unequally provided with organs. When the fission is in a longitudinal direction, the line of division generally passes through the mouth, more particularly in those genera in which that organ is situated at the bottom of a cavity. Sometimes the line runs on one side of the mouth, in which case one of the zooids has to develope an entirely new alimentary system for itself. In *Chilodon* the one zooid retains the mouth only, while the other has all the remainder of the alimentary system. *Stylonichia* divides across into a fore and aft part. The individual multiplying in this way seldom shows any difference in its behaviour, and retains its usual activity; but *Vorticella* is one of the few genera which afford exceptions in this respect. The members of this genus contract themselves upon their pedicle, and draw the peristome over the cilia, so as to shut themselves in. It has been frequently stated that the cilia are absorbed, but this is not the case; they are only covered over. The reader may readily convince himself of this by examining one of these creatures, when in this condition, under a good microscope. If the light be properly arranged, he will be able to see the cilia still vibrating beneath the transparent covering that closes them in. In this genus, as also in *Carchesium*, the division is so oblique that one zooid may frequently have all the pedicle muscle, while the other has none of it. In *Zoothamnium*, on the contrary, the division is strictly bilateral, and each individual has an equal share of the pedicle. This last mode is of great interest, for in those species in which the resulting zooids so formed remain attached to their parent stock we get those arborescent groups and social colonies so familiar to the microscopists. It is probable that the same explanation may also account for similar dendritic clusters so prevalent amongst the *Polyzoa*, *Hydrozoa*, and *Actinozoa*. There are some genera which develope in this way, and yet do not form arborescent groups, on account of the zooids always detaching themselves. As will be seen, there is a great variety shown even in this simple mode of reproduction; but whether the individuals divide in an oblique, transverse, or longitudinal direction, or whether the zooids so developed are equal or unequal in size, there is one constant character which accompanies every method of multiplication. This constant character is that the fission is always developed internally before any external signs show themselves. A second contractile vesicle, and a second mouth and œsophagus (when wanting), are always developed before external fission commences, but the nucleus remains unaltered up to the moment when the body is being divided, and then it is cut in two. There is a phenomenon, that of *zygosis*, which has frequently been confounded with fission, but, as will be presently shown, the two things are essentially distinct. This circumstance is mentioned here in order to point out that in those species in which fissiparity is rare, *zygosis* is of common occurrence, and *vice versâ*.

The method of multiplication by the development of buds or gemmæ cannot be considered as essentially distinct from that by fissiparous division, since they pass so gradually one into the other that cases arise in which it is impossible to distinguish by which method multiplication is being carried on. Nevertheless, it is found convenient to treat the two methods as if they were distinct, and to regard that as fissation in which the new animal acquires a part of the old nucleus; and that as gemmation in which it either acquires a newly-formed portion of the old nucleus, or else forms an entirely independent one. The most remarkable point connected with gemmation is its prevalence in the highest Infusorian family, and its rare occurrence in any of the others. Thus amongst the Acinetans it is only known in *Podophrya quadripartita*, and in the other families it has been seen in *Dendrosoma radians*, *Spirochona gemmipara*, and probably in *Uvella* and *Dinobryon*. In the *Vorticellidæ* the bud first appears as a small external swelling usually near the posterior extremity of the body. It is formed from the parenchyma, and is provided with a cavity which is in direct communication with the general cavity of the parent stock. The bud increases in size, and in some cases becomes as large as the body which bears it. As it becomes more and more like its parent, it developes a contractile vesicle and a nucleus; the cavity is soon after closed in, a circlet of cilia appears near the posterior end, the zooid detaches itself, and swims off to some other locality. A somewhat different series of phenomena occurs in *Dinobryon*. In this genus each monad lives in a cylindrical cell, and gives rise to another monad (by gemmation), the cell of which is attached to the upper edge of an older cell. The consequence is that the Infusorian colony which is ultimately formed closely resembles in form the polypidom of a *Sertularia*.

The third process of reproduction, viz., that by internal embryos, now remains to be considered. Like fissiparity, it is very general in all the *Infusoria*; but, unlike fissiparity, it is closely connected with the nucleus. Amongst the group of which we are treating it is very common to find two individuals grown together, as represented in *fig.* 5. This appearance has usually been attributed to a process of fission; that is, the mass has been regarded as one individual separating in two, whereas it is really two individuals interblended together. This phenomenon is called *zygosis*, and sometimes conjugation, by those who consider it to be directly connected with reproduction. It was first noticed by Leclerc, in 1805, and subsequently by Kölliker, Cohn, Stein, Claparède, and Lachmann. It is by no means peculiar to *Infusoria*, since it has been seen in *Actinophrys* amongst the Rhizopods, and in the *Palmellaceæ*, *Desmidiæ*, and *Zygnemaceæ* amongst the lower plants. Amongst *Infusoria* it has been seen in *Paramecium*, *Trichoda*, *Cyclidium*, *Coleps*, *Prorodon*, *Nassula*, *Lacrymaria*, *Amphileptus*, *Chilodon*, *Aspidisca*, *Euplotes*, and several other genera, more especially those belonging to *Acinetina* and *Vorticellidæ*. In most cases the union takes place at the fore part of the body, but in some along the whole length of the body. In the *Vorticellidæ* it begins by two individuals simply touching each other (but without any perceptible organic union resulting), and suddenly contracting upon their pedicles. In this position a bridge of matter forms between them, and fusion slowly proceeds, but more rapidly in the anterior than in the posterior half. While this is going on both individuals make rapid and vigorous contractions. When they have become so completely fused that no external signs can be detected of their double origin, a circlet of cilia is developed round the hinder part of the body. The contractions gradually diminish in frequency and intensity, and the blended mass, or *Zygozoite*, as it is called, detaches itself from its two stalks or pedicles, and swims away. After a time it fixes itself again, and sometimes encysts. This curious process has not been satisfactorily explained, and there are many reasons for believing that it has no essential connection with reproduction; the most prominent is that many *Vorticellæ* and *Acinetæ* reproduce without turning into Zygozoites.

The nucleus which has already been briefly described, and has been repeatedly mentioned in the course of this article, is represented in *fig.* 4 as it occurs in *Vorticella microstoma.* It is usually of a roundish shape, but sometimes it forms a long curved riband. It is enveloped in a peculiar membrane, and generally presents a homogeneous or finely granular appearance. A short time before the appearance of embryos the nucleus swells up and divides into two or more portions, but generally into two only. A minute vesicle soon appears in the separated portion, which developes into the embryo. When the nucleus breaks up into several portions, several small embryos are developed instead of a single large one. Except in size, there is no perceptible difference in the two kinds, although many observers are disposed to consider them as the results of two distinct methods of reproduction.

We will now pass on to the organ called the *nucleolus,* which was first described by Siebold, and afterwards seen by Stein in *Prorodon.* Lieberkühn has described its appearance in *Ophryoglena flavicans* as being like a grain of barley, marked at each end with a few streaks, and having a length of one-fiftieth of a millimetre. It is not quite as refractive as the fat globules, but it is more so than the rest of the body. In this and one or two other genera it is situated in the centre of the nucleus, but in most cases it appears to be situated close to the nucleus. Recent observations, to be noticed presently, seem to indicate that the nucleolus is the male generative organ.

It is quite beyond our limits to enter into the variations presented in the different genera, but we may give an outline of what is known respecting the reproduction of *Epistylis,* as observed by Claparède and Lachmann; and of *Paramecium,* as observed by Balbiani. In colonies of *Epistylis* there may generally be noticed two types, which may be distinguished by the one being of light and the other of heavy proportions. On the sides of most individuals one or two, apparently open, tumours may be seen; and close observation shows that every one of these contains one or more embryos, each of which possesses a contractile vesicle. They seem to be in a cavity filled with a fluid of greater density than that contained in the general cavity of the body. They possess cilia, by the aid of which they keep constantly whirling on their axes. If watched for a few hours, an embryo may be seen to escape through the tumour, and swim through the water. It possesses a circlet of cilia, and closely resembles the embryo of the *Acinetæ.* Hitherto embryos have been detected in the slender form only, and it is supposed they may be confined to the individuals of this type. In *Paramecium* the series of changes appear to be closely analogous. Two individuals unite by their mouths and move rapidly about. The nucleolus gradually increases in size, and ultimately assumes the form of an ovate capsule having a striated appearance. According to Claparède and Lachmann, the striations are due to a number of vibrio-like bodies contained in it, which bodies have been hypothetically supposed to be spermatozoa; this view, however, requires further confirmation. It should be mentioned that some of these bodies have been seen in the nucleus. Stein says that the spermatozoa are developed in the nucleolus, and that on quitting it they penetrate the nucleus, which then swells up, and the spermatozoa disappear. Balbiani also is in favour of their being spermatozoa. Whatever they may be, the nucleolus, after it has attained a certain size, divides into two or four parts, each of which increases independently, and originates a number of secondary capsules. Simultaneously with these changes the nucleus also enlarges, becomes more rotund, wider, and of a softer consistence; numerous transparent vesicles, each having a central dot, are also formed in its interior. Occasionally the nucleus breaks up into fragments before the vesicles have made their appearance. Subsequently two *Paramecia* make an interchange of their secondary capsules by passing them from the body of the one into that of the other. The capsules continue to enlarge in their new locality, but only one arrives at maturity at a time. Some days after the interchange minute rounded germs are seen attached to the body of the parent animal by means of suckers, which are dropped off when the embryos detach themselves, and are replaced by a mouth and a set of vibratile cilia, when the embryo assumes the form of the parent from which it sprung.

There are a few phenomena we have not noticed, which are generally stated to be associated with methods of reproduction, but apparently upon insufficient grounds; we refer to the process of encysting. It was first made known by O. F. Müller, but Guanzati first published a description of it in 1796 in a pamphlet which was almost entirely overlooked until a translation was given of it in a German periodical. The article originally appeared in vol. xix. of the 'Opusculi Scetti sulle Scienze e sulle Arte,' Milano, 1796, pp. 3—21; and is still well worthy of perusal. In it Guanzati suggested that encystation was a preservative act, and that it only occurred when the surrounding condition of things was unfavourable to the well being of the *Infusoria,* since he found by experiment that he could make them encyst at pleasure by evaporating the water. It is true that reproduction frequently takes place during encystation, but the association is probably nothing more than the coincidence of two unconnected phenomena. Encysting is almost universal amongst the *Infusoria,* and owing to the similarity in the forms of the cysts, it requires great caution to make correct observations on them. The following illustration will serve to exemplify this. The colonies of many of the *Vorticellidæ* are infested with numerous Infusorian parasites, every species of which may undergo encystation; but a knowledge of the laws of growth in *Infusoria* will enable any one to discriminate most of the parasitic cysts. For instance, we have already noticed that when an *Infusorium* reproduces by gemmation, and gives rise to a colony, a symmetrical form is produced. In *Dinobryon,* a polypidom like that of *Sertularia* is produced, and in *Epistylis* we have another symmetrical form, depending upon the plan of growth, which is dichotomous. So that when a cyst does not occupy a position which harmonizes with this plan it certainly does not belong to *Epistylis.* But even when the cyst does occupy such a position it is not always safe to refer it to *Epistylis.* For on one occasion Claparède noticed certain cysts which occupied the terminations of the forks in a species of *Epistylis,* and which appeared to be different from the cysts he had usually seen in it. They were filled with a granular matter kept in constant circulation by means of cilia on its margin. The cysts were watched for a long time, but nothing was ever seen to proceed from them. So one morning Claparède placed a group of them under the microscope with the determination to watch it until something happened that would establish what the cysts developed into. He commenced observations at ten o'clock in the morning, and maintained a constant watch. At six o'clock in the evening he noticed the creature inside one of the cysts cease its movements. Shortly after the cyst opened and an animal slowly issued forth. It was an *Infusorium* ciliated on the whole of its surface, and possessed of numerous contractile vesicles. It evidently belonged to the genus *Amphileptus* (*Trachelius* of Ehrenberg). The same evening three or four other individuals escaped from the cysts, all of which were of identically the same form as the first. Each of them passed a few minutes in great activity, and then gradually assumed a spherical form, at the same time turning on its axis with a peculiar motion, which has been frequently observed in *Infusoria* about to encyst. This encysting a second time so soon after its escape is probably abnormal, and due to the space being too confined. In order to confirm the accuracy of these observations other species of *Vorticella* with cysts were sought for, and *Carchesium polypinium* proved to be the most convenient. A number of these were watched from ten o'clock to eight o'clock, when the contents escaped as *Amphilepti.* These roamed about for a short time, and again encysted. The real connection between *Amphileptus* and *Epistylis* became evident by what was seen on a subsequent evening. An *Amphileptus* swimming about suddenly pounced on a colony of *Epistylis,* and attacked an individual. It opened its large mouth, which can only be seen on occasions of this kind, and glided on to the *Epistylis* like a glove on a finger. The cilia on its surface then commenced the peculiar movement so characteristic of the preparation for encysting. After some minutes a strongly defined line was seen round the creature which thickened until the cyst was completed. The *Amphileptus* then made a number of semiturns, first to the right and then to the left, apparently endeavouring to wrench the *Epistylis* off its stalk. These observations were repeated over and over again, and have been abundantly confirmed by Engelmann, Cienkowski, and others. From these facts it may be safely concluded that the *Amphileptus*-like bodies which issue from cysts on *Epistylis* have no genetical relation to *Epistylis.* These observations appear to suggest a doubt as to the correctness of Stein's opinion that *Epistylis* and *Acineta* are different forms of the same species. The great importance of this position, if true, has already been dwelt upon in the article in the Cyclopædia [INFUSORIA]. Stein noticed the frequent occurrence of

Podophrya quadripartita on colonies of *Epistylis*, and also that at one time a certain species would be the prevalent form in an aquarium, while a few weeks after perhaps it would have almost entirely disappeared, while some other species would be the prevailing form. This phenomenon occurred so frequently that he inferred the replacing species was a metamorphosed form of the earlier species; and he was the more convinced of this since he frequently saw individuals which were intermediate in form between the two species. In no case, however, did he show satisfactorily that the one species was actually transformed into the other. The strongest evidence adduced by him was that on precisely the same spot where a colony of *Vorticellæ* had been there sprung up a colony of *Acinetæ*. This undoubtedly is very strong presumptive evidence, but it cannot be accepted as a proof of their relation until a *Vorticella* has been seen to change into an *Acineta*. One way of crucially testing the point is to isolate a particular species, and to watch the metamorphoses it passes through. But it is an exceedingly difficult thing to ensure perfect isolation; Lachmann succeeded in doing it a few times only in the course of eight years. He effected it with *Vorticella microstoma, campanula*, and *nebulifera; Carchesium polypinum; Epistylis plicatilis*, and *Opercularis nutans*. On each occasion he isolated twenty or thirty individuals in a small glass tube or in an object glass. In this way he frequently obtained cysts of *Vorticella microstoma*, but no *Acinetinæ* were ever obtained. From the cysts of *V. microstoma* unaltered *Vorticellæ* escaped. He also tried similar experiments with *Acinetæ*. He usually isolated each *Acineta* containing one or two embryos in a drop of water on an object glass, and watched the escape, roving, and ultimate quiescence of the embryo. In no case did he see an *Acineta* turn into a *Vorticella*. Cienkowski has arrived at a similar result. As it might be objected that the confined space is in some cases prejudicial to development, Lachmann isolated a group of large *Acineta ferrum-equinum* in a small glass tube along with a few specimens of *Paramecium aurelia* and *P. bursaria* for them to feed upon, and a *Lemna minor* to keep the water fresh. This experiment was repeated many times, but it was frequently found that one or two specimens of *Vorticella* had also been introduced by accident. Two of these experiments gave a clear result; one of them was given up at the end of a week; the other at the end of seven weeks. During these periods the *Acinetæ* increased rapidly, yet no *Vorticellæ* could be detected. There can be no doubt, then, that Stein's acinetiform hypothesis is based upon error. It may be mentioned that Stein himself has candidly admitted the justice of this conclusion. And although Stein's hypothesis turns out to be incorrect, it should never be forgotten that science is under deep obligations to him for the great aid he has given to the naturalist in understanding the structure of the *Infusoria*. The figures in his works are much superior to those of Ehrenberg's where the internal conformation is concerned, and may be relied on for accuracy so far as his own actual observation goes.

We will terminate these remarks on generation by a few sentences from the work of Claparède and Lachmann. After referring to the existence of the two ways in which the *Infusoria* are reproduced, viz., by spontaneous division and by internal embryos, they ask what relation there is between them; or are they entirely independent of each other. Is it a matter of chance if an individual multiplies by the one way or the other? This last supposition is very improbable. It is far more likely that each mode occurs at certain definite periods in the life of the individual. In *Epistylis*, for instance, we have seen an indication of some such law. An individual issuing as an embryo *Epistylis* fixes itself, and gives rise to a family by fissiparous generation; and it is only individuals on a well-developed tree that form embryos. But there is more to notice. A tree of *Epistylis*, which has increased to a certain size, does not necessarily increase by embryos. On the contrary, it is only in exceptional cases that they increase in this way. Generally the individuals develope a circlet of cilia, swim away from the tree, and found other families elsewhere by fissiparous generation; and the trees so formed are more likely to throw off ciliated individuals than to develope embryos; but how long this process may continue has not been ascertained. In all probability it has a limit at which multiplication by embryos becomes necessary for the continuation of the species. What difference is there between these two processes? It is that in the one case the young are formed by internal, in the other by external, gemmiparity; that in the one external buds are formed at almost any part of the body, but in the other they always originate from a special part, the nucleus, which must be regarded as a generative gland. If the latter process should prove to be an asexual one, it is at any rate due to the specialization of a particular part. It is possible that the phenomenon of zygosis may have a bearing on the question of sexuality. It has been noticed in many genera, and may turn out to be of general occurrence. How far the process is connected with fecundation is uncertain; for although embryos have been seen just after its occurrence, yet in other cases embryos have been developed, although no zygosis has taken place. The existence of sexes, although more probable than before, is yet doubtful; and the existence of alternation of generation, as understood by Steenstrup, is yet to be shown. Steenstrup's notion of alternation of generation is reproduction by asexual processes, followed by reproduction by sexual processes. There may be a cycle of changes, as in *Epistylis*; but there may, or may not be, an alternation of generation. There exist then cycles of generations in the ciliated *Infusoria*, and, doubtless, also in the *Rhizopods*, which are comparable with those in the *Algæ*, and the flagellated *Infusoria*. In many *Algæ* and flagellated *Infusoria* a series of generations by simple division is followed by a transition generation, produced either by a conjugation, as in *Zygnema, Desmidiæ, Diatomaceæ;* or without a conjugation, as in the *Volvoces, Euglenæ*, &c.; and this generation commences a new cycle.

Among the more recent attempts at classifying the *Infusoria* are those of Bronn and Claparède and Lachmann. Bronn states the number of species known to be very nearly 600, and he distributes these amongst 140 genera. The following is his synopsis of the families:—

Flagella (long whip-like filaments), 1 to 6 in number, and always at the fore end. Mouth absent. Pigment spots rarely two, generally one, or absent	I. *Flagellata* or *Astoma.*
. Cilia generally wanting, except in *Trichomonas.*	
. . Animals without a temporary carapace; generally in the enjoyment of free locomotion, but at times fixing themselves; or if, connected, it is only by means of their flagella, and while they are undergoing fissiparation (as in Family I.)	
. . . Surface clammy, irregularly uneven; body homogeneous, flexible, and changeable in form; seldom possessed of external appendages. (In a few of the smallest doubtful forms no flagellum has been detected)	1. *Monadina, Eb.*
. . . Surface firm, in a tough, scaly skin.	
. . . . Body form not changeable.	
. . . . . Scales not siliceous, and not distinguishable from the upper rounded body mass	2. *Cryptomonadina, Eb.*
. . . . . Scales soft, afterwards siliceous (?), hard, open in front for the flagella (fissation inside the shell)	3. *Thecomonadina, Prt.*
. . . . Body form very changeable; scales thin-skinned, smooth, or regularly striped	4. *Astasiæa, Eb.*
. . Animals in a wide open cup-shaped carapace; the younger cups supported on the edge of the older ones, the whole forming a firmly fixed little tree	5. *Dinobryina, Eb.*
. Cilia outside the erect flagella, and situated in one or two hard scaly ring-like surrounding furrows	6. *Peridinæa, Eb.*
Flagella absent. Cilia constant: a mouth in all but a few genera. (Fam. 8.) Pigment spot in one genus only	II. *Ciliata*, or *Stomatoda.*

. Body movements slightly regular. Locomotion free, swimming, sometimes creeping or parasitic. Anus separated from, and placed behind the mouth . A. *Monima, Prt.*

. . Cilia unaccompanied by other organs of locomotion (sometimes vibratile setæ. "Schnell-Borsten.")

. . . Mouth wanting, or unknown; cilia scattered and feeble . . . . 7. *Cyclidina.*

. . . . on the fore end of the body, and not indented.

. . . . . Scaly skinned . . 8. *Colepina, Eb.*

. . . . . Not scaly skinned . 9. *Enchelyina, Eb.*

. . . . on or behind the fore end, with long folds inside, and with a jagged edge in front . . . 10. *Chilodontina.*

. . . . on the front edge, and continued like a fissure on the under side; not jagged . . . . . 11. *Tracheliina, Eb.*

. . . . confined to the ventral side; not jagged . . 12. *Colpodina, Eb.*

. . Locomotive organs placed together. Mouth beneath, or wanting.

. . . Without scales . . . 13. *Oxytrichina, Eb.*

. . . Scaly skinned . . . 14. *Euplotina.*

. Body movements partly regular, and partly equally rapid (in all); animals stationary or suctorial; mouth and anus in front, behind a spiral row of cilia B. *Spastica, Prt.*

. . Mouth and anus separated at the fore end, the one being ventral, the other dorsal; surface of body covered with longitudinal rows of fine cilia . . . . . 15. *Stentorina.*

. . Mouth and anus placed together in a vestibulum underneath the anterior surface of body, without cilia . . . . 16. *Vorticellina.*

APPENDIX.

Flagella, cilia, locomotive organs and mouth absent. The individuals fix themselves on bodies having a slight degree of motion; when arms are knobbed they are blood-suckers; but sometimes they are slender threads, and less frequently knotty . . III. *Acinetæ.*

Bronn then proceeds to give a synopsis of the genera, but as this is too lengthy for our columns, we will pass on to Claparède and Lachmann's classification :—

INFUSORIA.

NON-FLAGELLATED.		WITH ONE OR MORE FLAGELLA.	
Ciliati, With cilia or cirrhi in the adult state; no suckers.	*Suctoria,* No cilia in the adult state; with suckers.	*Cilioflagellata,* With cilia in addition to the one, two, or more flagella.	*Flagellata,* No cilia.

						Families.
CILIATA.	Mouth and œsophagus not dilatable; open in the state of repose. Œsophagus ciliated.	Mouth and anus in a common pit. Buccal spire dextrotropal				*Vorticellina.*
		Mouth and anus not situated in a common pit. Buccal spire lævotropal.	Body with buccal cirrhi only; rest of the body smooth.	No other locomotive organs besides the buccal cirrhi		*Urocentrina.*
				With other locomotive organs besides the buccal cirrhi. Motion walking		*Oxytrichina.*
			Bodies ciliated all over.	Bodies bell-shaped, with the buccal cirrhi arranged in several turns on its edge . . .		*Tintinnodea.*
				Buccal spire, when it exists, forming one turn only before reaching the mouth.	Buccal spire formed by cirrhi stronger than the cilia on the surface of the body.	*Bursarina.*
					No buccal spire formed on the external surface . . .	*Colpodea.*
	Mouth and œsophagus very dilatable; generally closed when at rest; œsophagus not ciliated.	Bodies entirely or mostly ciliated.	With a foot			*Dysterina.*
			Without a foot.	not cuirassed . .		*Trachelina.*
				cuirassed . . .		*Colepina.*
		Body smooth, furnished with one row of cilia round the mouth				*Halterina.*

FAMILY I.—VORTICELLINA.

						Genera.
Without a posterior circlet of cilia during the greater portion of life.	NAKED VORTICELLINA. 1st Sub-family: *Vorticellea.*	Pedunculated.	Pedicle contractile.	Not ramified		1. *Vorticella.*
				Ramified.	Each branch with its own muscle . .	2. *Carchesium.*
					One muscle only ramifying through all the branches of the colony . . .	3. *Zoothamnium.*
			Pedicle non-contractile			4. *Epistylis.*
		Non-pedunculated.	Posterior part with a circular sphincter			5. *Scyphidia.*
			Without an expansion or sphincter			6. *Gerda.*
	CUIRASSED VORTICELLINA. 2nd Sub-family: *Ophrydina.*	No true test.	Peduncle imbedded in a gelatinous mass			7. *Ophrydium.*
		With a true test.	Animal fixed to the base of its test.	Test fixed by the posterior extremity .		8. *Cothurnia.*
				Test fixed by the side		9. *Vaginicola.*
			Animal freely suspended in the test			10. *Lagenophrys.*
Furnished with a posterior circlet throughout life.	FREE VORTICELLINA. 3rd Sub-family.—*Trichodina*					11. *Trichodina.*

The genera (12) *Spirochona*, and (13) *Trichidonopsis*, are doubtfully placed in this family.

FAMILY II.—UROCENTRINA.

Consists of one genus only, viz. (14), *Urocentron.*

FAMILY III.—OXYTRICHINA.

Marginal cirrhi present.	Feet cirrhi in regular rows, longitudinal or oblique.	Anterior part not prolonged in a bundle of setæ	15. *Oxytricha.*
		Anterior part prolonged in a bundle of setæ	16. *Stichochaeta.*
	The uncini not distributed in regular rows		17. *Stylonichia.*

Marginal cirrhi absent.	Frontal cirrhi present.	The uncini	Not dorsal	18. *Euplotes.*
			Dorsal	19. *Schizopus.*
		Without uncini		20. *Campylopus.*
	Frontal cirrhi absent			21. *Aspidisca.*

FAMILY IV.—TINTINNODEA.

This consists of but one genus . . . . 22. *Tintinnus.*

FAMILY V.—BURSARINA.

With a test for a longer or shorter period during life. 1st Sub-family :—*Stentoria.* Anus in front.	Body not truncated in front by a large surface.	Buccal spire carried by a straight process						23. *Chætospira.*
		Buccal spire carried by a bilobed expansion						24. *Freia.*
	Body truncated in front by a large surface, which carries the buccal spire on its edge							25. *Stentor.*
Without a test. Anus behind. 2nd Sub-family :—*Bursaria.*	No lens-shaped organ.	No row of cilia in the inside of buccal groove.	Front not formed with a ridge.	Body truncated in front by an oblique surface, which carries the buccal cirrhi on its edge				26. *Leucophrys.*
				Body not truncated in front.	Buccal groove without a bundle of cilia in front.	Deprived of cilia on right side.	Body linear	27. *Spirostomum.*
							Body not linear	28. *Plagiotoma.*
						With cilia on the right side.	Body elongated, of same width throughout.	29. *Kondylostoma.*
							Body globular, narrowed in front.	30. *Balantidium.*
					Buccal groove very large, furnished in front with two bundles of cilia distinct from the buccal cirrhi			31. *Lembodium.*
			Front ridged, arching over the buccal groove.	Buccal groove oblique				32. *Metopus.*
				Buccal groove not oblique				33. *Frontonia.*
		Buccal groove funnel-shaped, carrying a row of short cirrhi on its interior						34. *Bursarius.*
	A lens-shaped organ near the mouth							35. *Oyhryoglena.*

FAMILY VI.—COLPODINA.

No membranous lips.	No setæ springing from the mouth			37. *Paramecium.*
	Setæ springing from the mouth.	A bundle of short setæ forming a lower lip		38. *Colpoda.*
		Setæ isolated and long on the upper part of the mouth.	No bundle of setæ on ventral surface	39. *Cyclidium.*
			A bundle of setæ on ventral surface	40. *Pleuronema.*
Mouth situated between two membranous lips which are constantly undulating				41. *Glaucoma.*

FAMILY VII.—DYSTERINA.

Cuirassed.	Two distinct valves		42. *Iduna.*
	Two valves soldered together.	Soldered behind only	43. *Dysteria.*
		Soldered all along the back	44. *Ægyria.*
No cuirass			45. *Huxleya.*

FAMILY VIII.—TRACHELINA.

Mouth terminal.	Anterior part with a conical appendage.	Body more or less cylindrical; in swimming turns on its axis.	Mouth at the summit of the appendage		46. *Lacrymaria.*
			Mouth at the base of the appendage		47. *Phialina.*
		Body flattened; swims without turning on its axis			48. *Trachelophyllum.*
	Without a conical appendage.	No swallowing apparatus.	No leaping seta.	body narrowed in front	49. *Enchelys.*
				body not narrowed in front	50. *Holophrya.*
			With a leaping seta behind		51. *Urotricha.*
		With a swallowing apparatus.	Body narrowed anteriorly		52. *Enchelydon.*
			Body not narrowed anteriorly		53. *Prorodon.*
Mouth not terminal.	With a swallowing apparatus.	No bundle of cilia.	Body never strongly depressed		54. *Nassula.*
			Body strongly depressed		55. *Chilodon.*
		A bundle of cilia forming a kind of foot			56. *Trichopus.*
	No swallowing apparatus.	With a row of spherical vesicles, each vesicle containing a highly refracting corpuscle			57. *Lozodes.*
		Without such vesicles.	No limbs.	Intestine ramified	58. *Trachelius.*
				Intestine not ramified	59. *Amphileptus.*
			A large peripherical limb, formed by compact parenchyma		60. *Loxophyllum.*

FAMILY IX.—COLEPINA.

Consists of one genus only . . . . 61. *Coleps.*

FAMILY X.—HALTERINA.

Fine setæ used for leaping	62. *Halteria.*
Animal without leaping setæ, locomotion by swimming not leaping	63. *Strombidion.*

ORDER II.

FAMILY I.—ACINETINA.

Suckers not carried by a proboscis.	Suckers not ramified.	No ramified colony.	No test.	A pedicle		64. *Podophrya.*
				No pedicle.	Free	65. *Sphærophrya.*
					Fixed	66. *Trichophrya.*
			A test.	A pedicle		67. *Acineta.*
				No pedicle		68. *Solenophrya.*
		Forms a ramified colony				69. *Dendrosoma.*
	Suckers ramified					70. *Dendrocometes.*
Suckers carried by a large retractile proboscis						71. *Ophryodendron.*

ORDER III.

FAMILY I.—PERIDININA.

With a transverse groove in cuirass.	Two halves of cuirass of nearly equal length.	Cuirass armed with horns	72. *Ceratium.*
		Cuirass without horns	73. *Peridinium.*
	Two halves unequal.	Edges of groove raised into a plate	74. *Dinophysis.*
		Edges not raised	75. *Amphidinium.*
No transverse groove.	Cilia on the anterior edge		76. *Prorocentrum.*

The most important recent work on this group is that of Stein's—'Der Organismus der Infusionsthiere nach eigenen Forschungen in systematischen Reihenfolge bearbeitet,' of which the first part was published in 1859, and the second in 1867. We have not been able to see the second part, but his mode of grouping is thus given in the 'Record of Zoological Literature for 1867.'

Order I. PERITRICHA, Stein.

Family 1. *Ophryoscolecina.* Genera: Ophryoscolex, St.; Entodinum, St.

Family 2. *Spirochonina*, St. Genus: Spirochona, St.

Family 3. *Ophrydina*, E. Genera: Lagenophrys, St.; Cothurnia, E.; Vaginicola, E.; Ophrydium, E.

Family 4. *Vorticellina*, E. Genera: Opercularia, E.; Epistylis, E.; Zoothamnium, E.; Carchesium, E.; Vorticella, E.; Scyphidia, Lachm.; Gerda, Clap. and Lachm.; Astylozoon, Engelm.

Family 5. *Urceolarina*, St. Genera: Urceolaria, St.; Trichodina, E.; Trichodinopsis, Clap. and Lach.

Family 6. *Gyrocorida*, St. Genus: Gyrocoris, St.

Family 7. *Cyclodinea*, St. Genera: Urocentrum, E.; Didinium, St.; Mesodinium, St.

Family 8. *Tintinnodea*, Clap. and Lachm. Genera: Tintinnus, E.; Tintinnopsis, St.

Family 9. *Halterina*, Clap. and Lachm. Genera: Halteria, Duj.; Strombidium, Clap. and Lach.

Order II. HYPOTRICHA, St.

Family 1. *Oxytrichina*, E. Genera: Psilotricha, St.; Oxytricha, E.; Stylonichia, E.; Onychodromus, St.; Pleurotricha, St.; Gastrostyla, Engelm.; Uroleptus, E.; Stichotricha, Perty; Kerona, E.; Epiclintes, St.; Urostyla, E.

Family 2. *Euplotina*, E. Genera: Euplotes, E.; Styloplotes, St.; Uronychia, St.

Family 3. *Aspidiscina*, E. Genus: Aspidisca, E.

Family 4. *Erviliina*, Duj. Genera: Ervilia, Duj. (Iduna, Clap. and Lachm.; Dysteria, Huxley); Trochilia, Duj.; Huxleya, Clap. and Lach.

Family 5. *Chlamydodonta*, St. Genera: Scaphidiodon, St.; Chlamydodon, E.; Phascolodon, St.; Trichopus, Clap. and Lachm.; Opisthodon, St.; Chilodon, E.

Family 6. *Peritromina*, St. Genus: Peritromus.

Order III. HETEROTRICHA, St.

Family 1. *Spirostomina*, St. Genera: Condylostoma, Duj.; Blepharisma, Perty; Spirostomum, E.; Clinacostomum, St.

Family 2. *Stentorina*, St. Genera: Stentor, E.; Freia, Clap. and Lachm.

Family 3. *Bursariea*, St. Genera: Bursaria, E.; Balantidium, Clap. and Lachm.; Nyctotherus, Leidy; Metopus, Clap. and Lachm.; Plagiotoma, Duj.

Order IV. HOLOTRICHA.

Family 1. *Cinetochilina*, St. Genera: Lembadion, Perty; Pleuronema, Duj.; Plagiopyla, St.; Cyclidium, E.; Trichoda, E.; Pleurochilidium, St.; Cinetochilina, Perty; Glaucoma, E.; Ophryoglena, E.

Family 2. *Paramæcina*, St. Genera: Panophrys, Duj.; Leucophrys, E.; Colpidium, St.; Isotricha, St.; Conchophthirus, St.; Ptychostomum, St.; Colpoda, E.; Paramæcium, E.; Nassula, E. (Acidophorus, St.; Cyclogramna, Perty; Losiphon, E.); Cyrtostomum, St.

Family 3. *Enchelina*, St. Genera: Prorodon, E.; Holophrya, E.; Actinobolus, St.; Urotricha, Clap. and Lachm.; Perispira, St.; Plagiopogon, St.; Coleps, E.; Enchelys, E.; Enchelyodon, Clap. and Lach.; Lacrymaria, E.; Phialina, E.; Trachelocerea, E.; Trachelophyllum, Clap. and Lachm.

Family 4. *Trachelina*, St. Genera: Dileptus, Duj.; Trachelius, E.; Loxodes, E.; Loxophyllum, Duj.; Amphileptus, E.

Family 5. *Opalinina*, St. Genera: Haptophrya (Discophrya), St.; Anoplophrya, St.; Hoplitophrya, St.; Opalina, Purk. and Val.

(Balbiani, *Comptes Rendus*, xlvi., p. 628; Carter, *An. and Mag. of Nat. Hist.*, 2nd series, vol. xviii., p. 115, 221—vol. xix., p. 259—vol. xx., p. 34;—3rd series, vol. viii., p. 281; Lieberkühn, *Müller's Archiv* for 1856; Greene, *Manual of the Protozoa;* Bronn, *Die Klassen und Ordnungen der Thier-reichs*, Erster Band; Lachmann, *Müller's Archiv* for 1856, p. 340; Claparède and Lachmann, *Memoire sur les Infusoires et les Rhizopodes;* Leuckart, *Wiegmann's Archiv*, xxvii., p. 81; Wrzesnowski, *A. des Sci. Nat.*, 4th series, xvi., p. 427; Engelmann, *An. and Mag. of Nat. Hist.*, 3rd series, vol. x., p. 241; *Record of Zoological Literature*, vol. iv., p. 666.)

ITABIRITE is a rock consisting of specular iron, the most crystalline condition of hæmatite or native ferric oxide; micaceous iron, a flaky condition of the same substance; magnetite, the crystalline form of native ferroso-ferric oxide; and quartz. As accessory ingredients, or those which do not form an essential constituent of itabirite in its typical development, are talc, chlorite, actinolite, and gold. The type rock forms the peak of Itabira in Brazil. The name is also applied to other rocks which resemble more or less closely that at Itabira. Thus in South Carolina there is such a rock, which contains less quartz and more talc, the latter mineral being the matrix in which the magnetite crystals are embedded. Its accessory ingredients differ from those of the Brazilian example, as it contains mesotype, hyaline quartz, staurolite, &c. Then, again, there are numerous intermediate varieties between a rock in which the specular iron predominates, and a sandstone which contains specular iron, magnetite, and micaceous iron. In order to understand the true relations of itabirite to other rocks, it would be requisite to investigate the phenomena connected with the development of the crystalline form of oxide of iron in, or as, rock masses. Oxide of iron is a common ingredient in both stratified and unstratified collections of mineral masses, but the nature of the rock seems to have some influence in determining the kind of mineral formed, for in siliceous rocks the iron oxide mostly occurs as a crystalline hæmatite or ferric oxide; whereas when the silica is accompanied by bases such as magnesia, lime, &c., the ferric oxide is quite subordinate to magnetite, the ferroso-ferric oxide. Under certain conditions, of which little or nothing is known, the iron-oxide combines with the silica, and thus gives rise to a multitude of lithological varieties characterized by silicates. The rock called *Topanhoacanga* differs but little from itabirite. It is formed of specular iron, micaceous iron, and magnetic iron, cemented by some ferruginous compound; and contains fragments of quartz, itacolumite, clay slate, gold, &c. It occurs as a crust on the surface of the ground in various parts of Brazil. It is apparently a modern formation, arising from the detrition and reaggregation of the rocks of Brazil, itabirite contributing most largely to its composition. The itabirite of Brazil and South Carolina appears to form a portion of the Silurian series of strata.

(Cotta, *Rocks Classified and Described*, 1866; Lieber, *First Annual Report on the Geological Survey of South Carolina*, 1856; Delesse, *Études sur les Metamorphisme des Roches*, 1861.)

ITACOLUMITE is a kind of sandstone, which Cotta defines as being "a fine-grained and at the same time schistose compound of quartz with some mica, talc, or chlorite. In thin plates it is sometimes flexible." This rock is largely developed in Brazil where it forms the material of strata hundreds of feet thick, and hundreds of miles across in superficial extent. It is named after the mountain Itacolumi, near Villa Rica, which is almost entirely formed of it, its height being 5400 feet. In Georgia it is 300 feet thick, but is there varied by intercalated bands from one to three feet thick which abound in lumps and crystals of lazulite. It contains sufficient gold to induce persons to work it. In North and South Carolina it contains beds of talc schists, and richly ferruginous ingredients, constituting ferruginous mica schist, itabirite, catawbirite, &c. In Brazil, as well as in the United States, it occupies the same position in a similar sequence of beds. Thus in both it is overlain by a limestone, the lower beds of which contain intercalated talcose schists. In its stratigraphical relations and structural properties it has considerable resemblance to the Potsdam sandstone, more especially in its westernmost extension, where it becomes conglomerated, laminated, and presents other signs of being a shallow water deposit. The most remarkable feature about itacolumite is its flexibility, but this property is not regarded as a characteristic peculiarity, since of two specimens from the same bed the one may be flexible and the other rigid, although otherwise there is to the unassisted eye no difference which would warrant their being described as two kinds of rock. Generally the flexible portions are much finer in grain, and the talc is less abundant. There is every transition from the most rigid to the most flexible portions, and the latter occupy a far more limited area than the former. It also has a resemblance to the Chilhowee sandstone of Tennessee, which is believed to represent the Potsdam sandstone in that area. As the Potsdam sandstone gradually passes from the fine grained condition in Iowa to the coarse grained conglomeratic state in the far west towards the Rocky

Mountains, so the beds of itacolumite present the same transition, at least in some areas. Thus, in South Carolina, it is fine-grained and flexible in Spartanburgh county, coarse-grained and rigid in York county farther west, and conglomeratic still farther west, or in Union county. In this last locality it is a conglomerate with a micaceous arenaceous cement, in which the mica is so abundant that the pebbles are generally hidden by it on a fresh fractured surface. The pebbles consist chiefly of hyaline, but sometimes of saccharoidal, quartz, and have their long diameter parallel with the bedding of the strata.

The term itacolumite is usually restricted to the fine-grained portions of the quartzose deposits here noticed, but we have referred to its passage into conglomerates in order to indicate that the itacolumite itself is evidently a detrital deposit. It would seem to have been originally an accumulation of sand, which has since undergone alteration partly by pressure, and partly by infiltrating solutions.

The flexibility of itacolumite is not confined to thin plates, but is well displayed in large slabs, as is exemplified by a specimen in the British Museum. This property is usually attributed to the flexibility of the mica flakes which unite the grains of quartz, but that this explanation is not the true one has been demonstrated by Professor Wetherill. He procured a cylinder seven and three quarter inches long by half an inch in width. When squeezed or pulled with a moderate degree of force its length was altered by about the $\frac{1}{400}$th part, or what would amount to an inch in a slab between 33 and 34 feet long. If one end was fixed the other could be made to describe a circle nearly two inches in diameter; and it could be twisted to the extent of 10° of torsion. When supported by its two ends it becomes flexed into a curve intermediate between a true catenary and an ellipse. On examining prepared thin sections with a microscope they look like loose layers of sand, the grains of which are aggregated together into little clumps. Each group comprises from twenty to fifty sharp fragments of quartz feebly cemented together; and the groups are connected together by a series of cavities and projections, which Professor Wetherill compares to ball and socket joints with rough articular surfaces. Each joint permits a slight movement, but greater in one direction than another. The flexibility is increased in proportion as one dimension is less than the two others; so that it would be quite as marked in large sheets as in small plates. The flakes of mica were very few in number, and took no part whatever in determining the motion. The cement which unites the grains is not removed by boiling in hydrochloric acid, is partially disintegrated by a hot alkaline solution, and is almost immediately dissolved by a solution of hydrofluoric acid. These facts imply that it consists not of oxide of iron, but of some siliceous substance, probably hydrated silica. Heating the rock and then plunging it into water does not render it friable, nor does exposure to a red heat diminish its flexibility. The siliceous grains have about the same hardness as agate, but occasionally they are associated with something much harder, possibly small diamonds. The rock is eminently porous, water passing, and gases diffusing, through it with great facility.

If itacolumite is interesting on account of its flexibility, it is more so on account of its relations with the diamond. Specimens of this gem have been found in it in Brazil, South Carolina, and other localities; and the question arises whether they were formed in the rock or not. Professor Wetherill's description of the siliceous fragments as sharp, would seem to indicate that they had been subject to no attrition, but it seems probable that the grains may have acquired this form by crystallization subsequent to deposition, in the same way as the Potsdam sandstone and other ancient arenaceous beds consist of grains with crystalline facets, although in their case there is abundance of evidence to show their detrital origin. Jukes also notices that the mica in itacolumite occurs as worn spangles, so that these may have been derived from some other rock, although it is possible the worn appearance may be due to the action of natural solvents acting upon the mica in place. The presence of gold associated with magnetite and micaceous iron is also consistent with this view; indeed itacolumite and the associated richly hæmatitic beds strike one as all having been derived from the same rock mass, the materials of which have been re-sorted. If so, it may well be suggested that the diamonds have also been detached and transported from their original gangue, and that the itacolumite is not the rock in which diamonds originate. The main argument in favour of the opposite view is that the diamond is always associated with itacolumite, or with a conglomerate which contains fragments of a rock having the nature of itacolumite. To this we may add, what is scarcely an argument, that this rock answers the conditions which we should expect would facilitate the formation of diamonds. These conditions are a high degree of porosity, subjection at one time to an immense superincumbent weight, and the passage through the rock of some fluid which would carry off all the hydrogen, oxygen, and nitrogen of the hydro-carbonaceous materials, leaving all or a portion of the carbon behind in a crystalline state. These conditions conform with De Chancourtois' suggestions, [Diamond, E. C. S. col. 370], but differ therefrom in one point, which we consider essential, viz., the presence of great pressure. Professor Wetherill thinks the physical conditions which have led to the peculiar jointed character of itacolumite may have a bearing upon the crystallization of the diamond, and thus speculates in connection with this subject:—"It is difficult to see why the siliceous fragments cohere to form definite groups or congeries. If we suppose that planes having a certain relation to the crystalline axes cohere by long-continued contact more readily than planes having a different relation, why does this partial cohesion occur with such surprising regularity? why also is it not perceived in other sandstones? It would appear that the sand which formed the rock contained something diffused in a regular manner (and which was subsequently removed) which prevented the uniform contact of the siliceous grains. It is possible to conceive that petroleum might have that effect when added to sand of a certain degree of moistness, forming a kind of emulsion, and that the petroleum was afterwards slowly removed by a process which permitted a crystallization of a portion of its carbon. When water was dropped upon dry sand, the mixture when stirred formed lumps of uniform size; if, before stirring, a little petroleum was added, the lumps appeared to form more readily. The lumps are left out of aqueous contact by the coating of petroleum around each one, while the siliceous particles forming the lumps have water between their component grains. Cohesion could take place between the particles, but not between the lumps. Under the microscope the sand thus treated has a striking resemblance to itacolumite." The siliceous cement round the grains of itacolumite indicates the probable former presence of a solution of silica, which would take the place of the water in the foregoing experiment. The indentation of one collection of granules by another is apparently the result of pressure. Professor Wetherill noticed some minute black specks in his specimens, and asks if they are black diamonds, and if the deep scratching of his agate mortar was due to them. If so, these would represent the crystallized carbon.

(Cotta, *Rocks Classified and Described*; Lieber, *Annual Reports on the Geological Survey of South Carolina*, 1856—1860; Wetherill, *American Journal of Science and Arts*, Second Series, vol. xliv. pp. 61—68.)

J

JACARE. [CROCODILIDÆ, E. C. S. cols. 322, 323.]

JANTHINA [E. C. vol. iii. cols. 298—301]. The little group of oceanic mollusca to which this and the allied genus *Recluzia* belong, is regarded by some naturalists, and amongst them Mr. Gwyn Jeffreys, as a distinct family to which the term *Janthinidæ* or *Ianthinidæ* is applied. This authority places this family after the *Pyramidellidæ* and before the *Stiliferidæ*, and remarks that its affinity is with *Gasteropoda*, and not with *Heteropoda*.

The generic diagnosis in col. 299 requires modification. The pedicle at the base of the tentacle is not oculated; indeed, several good observers who have examined the living animal say that there are no eyes in the species examined by them. Benson and Jeffreys concur in this view. It is possible that the embryos have eyes, since Philippi expressly states there are two, which are large and black. The foot is oval in specimens which have been preserved in spirits, and which are consequently drawn up. In the living animal its shape is a long ellipse, being broader in front and tapering towards the opposite extremity. The natatory appendages alluded to are the lobes of the mantle, but it is very doubtful if they are used as organs of natation, for Benson, Jeffreys, Lacaze-Duthiers, Adams, all agree that the specimens seen by them never employed these parts for such a purpose under circumstances when they were most likely to require them. Forskål, however, has mentioned that the embryos have transverse lobes furnished with cilia, by whose vibration the animal is rowed from place to place, so that it seems that the expansion of the mantle is a rudiment of an organ which serves as the principal locomotive organ in the young, but affords little or no aid towards performing such functions in the adult. The vesicular appendage, or float, is not a modification of the operculum.

The geographical distribution of the genus has not been adequately worked out. The species appear to occur in all the seas of the tropical and temperate zones, but as yet they have not been detected in high latitudes. Most of them are sporadically distributed within their area of distribution; generally the individuals are scattered here and there, but with tolerable uniformity, over a few degrees of latitude and longitude, while none are to be seen in the intervals between the different isolated areas occupied by the same species. It is also noticeable that the individuals occupying these separated areas are frequently distinct varieties. Such are the conclusions we draw from the observations of Mr. Benson, which, however, were confined to a single rapid voyage, and it remains to be seen what support future observations will afford to them. *J. exigua* is, perhaps, the most widely distributed. It is found in the Atlantic, north of the Madeira Islands; in the South Atlantic, opposite Brazil, near the island of Tristan d'Acunha; also near those of St. Paul and Amsterdam, and again in the Bay of Bengal. It may arise from the accidents of the method of observation, but it seems that the captures are made, not precisely in mid-ocean, but in localities within a few hundred miles of some group of islands. It is observable that the specimens obtained in the north are usually smaller than, and sometimes differently tinted from, those captured in the south. Thus, near Madeira and off Bengal *J. exigua* is small, but is large near Tristan d'Acunha, and near the isles of St. Paul and Amsterdam. Benson captured specimens answering to Lamarck's *J. fragilis* in 3° N. lat., and 24° W. long., but the species was not again seen until the neighbourhood of the Andaman Islands was reached, or about 10° N. lat., and 95° E. long. Again *J. umbilicata* occurred in 1° and in 14° N. lat. in the Indian Ocean, but nowhere in the intermediate space. *J. pallida* was met with frequently in a tract extending from 30° S. lat. and 18° W. long. to 33° S. lat. and 10° W. long. Just at the southern limits of this area several large individuals were observed, but on the following day not one could be seen, nor was anything more seen of the species until the vicinity of St. Paul and Amsterdam islands, or about 39° S. lat., and 79° E. long.; but all the individuals seen here belonged to a pale and stunted variety. *J. cæruleata* and some of its varieties flourish between 33°—30° S. lat., and 81°—83° E. long., where it is associated with *Lepas fascicularis*, a small swimming-crab, and *Velellæ*. Curiously enough, all these species, belonging to different classes, are all tinged of a blue colour, as though there were something in the locality which caused most of the floating organisms frequenting it to acquire that tint; while the *Janthina* is bluer than almost any of its allies. It is suggested in E. C. that the blue tint of *Janthina* is derived from the blue *Velellæ*, on which it principally feeds; but this will not account for the other species being so coloured. The crabs make the *Velellæ* into temporary rafts; but they do not feed on these jelly fishes, nor do the individuals of *Lepas fascicularis*. Are the groups of *Janthinæ* really isolated, as they seem to be, or do stray individuals wander in all the intermediate seas? The apparent fact that each area is occupied by a distinct variety seems to indicate that the groups are isolated now; that at one time the species frequented a single area, and that since then some cause has brought about its dispersion, disruption, and, probably as a consequence, its divergence into varieties. It is doubtful if any species are really British; that is, if any habitually frequent the seas off our own islands. Shells of *J. communis*, *J. globosa*, *J. pallida*, and *J. exigua*, are found on the shores, but not one of them has contained the animal. Shells, with the animal of *J. rotundata*, are occasionally taken, but the animal has been either dead or dying, and these only occur on our western coasts; so that it would seem that the individuals are castaways brought here from their true home by the influence of the Gulf Stream. No specimen of *J. fragilis*, Lamarck, has reached England; the true habitat of this species is in the tropics.

Much has been said about the float of *Janthina*, more especially as to its mode of formation, and its connection with the animal. Dr. Coates's account, as given in E. C., is so strictly accurate, and has been so fully confirmed by Benson, Adams, and Lacaze-Duthiers, that scarcely anything further need be said, did we not wish to urge that the float is essential to the life of the creature. When a *Janthina*, deprived of its float, is placed in an aquarium, it immediately sinks, and lies at the bottom of the vessel struggling and moving about, but unable or unwilling to swim. If some of the individuals are very active, they will creep up the sides of the vessel, but, from inability to retain themselves at the surface, either by constructing a float, or by the action of the foot, as in *Limneæ*, they again sink to the bottom. If the vesicles of the float belonging to an individual possessing that organ be snipped with a pair of scissors so as to liberate the air, the animal sinks in the water in proportion to the extent of destruction, and when this has been carried to a certain point the animal is so far below the surface that it cannot extrude its foot into the air. If left in this state it cannot supply the damage done to the float, and soon dies. If the destruction is carried to the extent of quite, or nearly, annihilating the float, the animal sinks completely, and does not survive many days. All this seems very intelligible, when it is considered that the air of the float is not secreted from or generated in the body of the animal, but that it is derived from the atmosphere, and enveloped in mucus. Access to the air is essential to the formation of the float. The specific gravity of the animal with its shell is greater than that of sea-water; so that, as it has no other special means of flotation, it is unable to add to or reconstruct a float whenever its buoyancy is insufficient to allow of its reaching the air. This is partially proved by experiment, for if an individual without its float is sustained artificially partly below and partly above the surface of the water the whole process of making the float goes on before the observer's eye from beginning to end. The globules are formed and added to the float one by one, and the fresh ones are always attached to the anterior ends of the last which have been added. The operation can be at once brought to a stop as long as only a few globules have been collected, by removing the support, and letting the animal sink. After each globule has been fixed, the foot is invariably withdrawn into the water to be again projected into the air in a spoon-shaped form; this operation is evidently essential, but why we cannot say. As the float is simply agglutinated to the hind portion of the foot, the connection is readily broken; but the animal has no means of adding air to or withdrawing it from the globules, and whatever injuries are sustained are compensated by additions to the anterior end of the float. If the apex is lost it cannot be directly replaced, since the globule-forming part of the foot is not sufficiently long to reach it.

It is not known how the young contrive to commence the float. It is supposed that they climb on the float of the parent and derive support from it while beginning their own. This is only a supposition, and will apply as such only to the viviparous species. The young of the oviparous species are probably locomotive, and dwell habitually below the surface of the water, like the young of most gasteropods. When they discard their locomotive habits they probably cling to some object which will support them and thus aid them to reach the air while constructing their float. Benson confirms Coates's observation that each species has a distinctive float.

(Benson, *An. and Mag. of Nat. Hist.*, 3rd Series, vol. vi., p. 405; Adams, *An. and Mag. of Nat. Hist.*, 3rd Series, vol. x., p. 417; Lacaze-Duthiers, *A. des Sci. Nat.* 5th Series, vol. iv., p. 329; Jeffreys, *British Conchology*, vol. iv., p. 174.)

K

KAMES. A name frequently applied to ridges of gravel and sand, remarkable for the positions in which they occur, the embankment-like appearance which they present, and the prolonged discussions which have taken place as to their origin and mode of formation. It is possible that these ridges have different origins, but it is generally believed that what are termed kames in Scotland are identical with the *ösar* of Sweden, and the *eskers* of Ireland. Similar ridges occur in North America where they are called drift-mounds, gravel ridges, &c.

There is one example near Toronto, in Western Canada, which appears to throw some light as to the probable way in which some of the kames of Great Britain have been formed. Toronto stands on the north shore of Lake Ontario, the long diameter of which lake runs east and west. To the north of Toronto is a flat plain which extends inland for several miles, where it is bounded by a cliff of boulder-containing clay, known as the Davenport Ridge. This cliff stretches for some miles to the east, and then suddenly bends north, and runs in an irregular line so as to form a deep bay. On the opposite or western side of the bay the cliff continues parallel to the shores of the lake. At the eastern angle of the bay, and projecting westwardly from it in a line with the cliff is a ridge of gravel and sand two miles and a half in length, about one-eighth of a mile wide, from fifteen to twenty feet high, and with gently rounded summit and sides. It stretches more than half way across the mouth of the bay just described. The gravel is formed of the same materials as the rocky fragments in the clay composing the Davenport cliff; only in the cliff they are angular, while in the gravel ridge they are rounded. The rounded stones vary in size from coarse sands to pebbles two inches in diameter, and have evidently been produced from the angular stones in the cliff. The smaller particles were rolled along by currents to form the gravel ridge, the clay was washed into deeper water to form the plain near Toronto, while the large boulders remained behind, and now strew the ground at the foot of the terrace. In the gravel ridge there have also been found rounded nodules of clay, similar in character to that forming the cliff, and which appear to have been rounded when hardened by frost. The gravel is not deposited in horizontal layers, but the general dip is northerly or away from the lake towards the high land. All these phenomena indicate that this ridge was formed by the action of currents beating against the boulder-bearing clay cliff, which travelled westward, and deposited their load at the entrance of the bay. The northerly dip of the stratification in the ridge is due to the action of the ground-swell, piling up the stones, and forcing them over the beach into the stiller water on its north side. This took place when the waters of Lake Ontario were 170 feet above their present level. As a confirmation that the gravel ridge has been or may have been formed in the way indicated, a similar ridge is in process of formation at the present time in front of the harbour of Toronto. The gravel ridge, bay, and cliff on the higher ground, is in every essential respect paralleled by a gravel ridge, harbour, and cliff at the lower level. And, as shore currents are known to be the efficient agent in the one case, there is great probability they were engaged in the other.

Geikie describes the kames of Scotland as ridges of gravel running in a more or less sinuous line, having a length varying from a few yards to several miles, ranging from 20 to 60 feet in height, and rising abruptly from the ground. "Such a ridge," he says, "is often seen alone with no other mounds or ridges of detritus near it, keeping its course across a heathy flat, like an artificial dam or rampart, and conspicuous, not only by its form and size, but by the greenness of its slopes contrasting with the brown of the surrounding moor. I have never been able to trace any definite and persistent relation of these ridges to the form of the ground on which they occur. Sometimes, as on the north flank of Tinto, the ridge begins on a hill slope and extends away into the plain. Sometimes it runs parallel to the hill side, as below the west front of the beautiful cove of Quothquhan, near Thankerton. Again it may be seen rising up in a flat moor apart from any rising ground, as is admirably shown on the Carnwath moors, and on those to the south of Dirrington Law in Berwickshire. I have frequently observed, however, that these ridges ran across valleys and have been cut through by the streams. Examples may be seen in the Clyde valley at Thankerton, and at the junction of the Douglas Water, in the course of the Mouse Water (a tributary of the Clyde) near Ravenstruther, in the grounds of Dunse Castle, on the moors between Dunse and Westruther, and in many other localities. Yet other instances might be cited where the kames run along the line of the valley, especially if it be a flat and tolerably wide one. This may be verified in the course of the Medwin above Ogscastle, and on a much greater scale in the wide valley traversed by the Caledonian railway, between Auchengray and Carstairs. The Scotch kames are almost entirely composed of gravel and sand, generally stratified, and frequently false-bedded." The geologist, whose observations we have just quoted, recognizes two classes of kames in Scotland, viz. (1) those which consist wholly or nearly so, of coarse shingle, and (2) those that are made up of fine sand and gravel. The kames of the first group are sharper and higher in outline than those of the second; their stratification is obscure or barely perceptible; the stones which form it are usually large, with their surfaces more or less striated, but less distinctly so than in the boulders of the boulder clay. The kames of the second group are well stratified with dome-shaped outlines. Frequently layers or nests of clay highly laminated occur amidst the sand and gravel.

There is much similarity between these gravel ridges, and those which are forming at the present day in wide estuaries; but the great frequency of kames in countries which have formerly been the seats of glaciers seems to indicate some connection between them and the glaciation of these countries. It is believed by many that glaciers have been directly instrumental, but there does not appear to be any good grounds for this belief. Most of the kames of Scotland and Ireland seem to have been formed during the same geological period, viz., during the upheaval of the country prior to the formation of the peat bogs, but this is probably an accident of position; the older ones have been destroyed, and the recent ones are now submerged, and not recognized as kames. Chesil bank on the coast of Dorsetshire appears to be similar to what are termed kames.

KEUPER [E. C. vol. iii. col. 315], the upper portion of the triassic group of strata as developed in Western Europe. There is little doubt that the Red Sandstones alluded to in the original articles as occurring in Warwickshire and the neighbouring counties, correspond to the Keuper of Germany. The beds are generally scant of fossils, but those that have been met with mostly belong to terrestrial and fluviatile species, indicative of a rich and varied fauna. Marine fossils are almost absent, but there are some beds in Germany containing marine remains which are believed to be the marine equivalents of the reptiliferous and plant-bearing Keuper sandstones, and which are remarkable for the variety and abundance of the species which they contain. We allude to the Hallstadt and St. Cassian beds. But the principal palæontological feature of the Keuper is the astonishing variety of its reptiles. It is probable that the bone breccia of Somersetshire and Wurtemburg containing the earliest known mammalian remains, viz., *Microlestes antiquus*, and a few other species, appertain to the Keuper.

L

LABRADOR ROCKS. [LAURENTIAN FORMATION, E. C. S.]

LARYNX [E. C. vol. iii. cols. 350—355]. The larynx is more especially the organ of phonation, and together with the tongue and other parts of the mouth, it constitutes the apparatus by which articulation is effected. As a detailed account has already been given of the various parts of which the larynx consists, of the positions, attachments, and functions of the various muscles, we need not go over that ground again. As additional observations we may notice that a muscle passing from the thyroid cartilage to the sternum, the sterno-thyroidei, has an important share in aiding phonation. It acts by depressing the thyroid cartilage, and so imparting that increased tension of the larynx generally as will facilitate those rapid vibrations of the vocal cords which result in the production of the highest notes. The position of the epiglottis is normally semi-erect, but in many persons it assumes a more depressed or horizontal position so as to diminish the area through which the air passes through the laryngeal orifice. This is accompanied by inconvenience if not by predisposition to certain diseases. A person with a pendent epiglottis, other things being equal, will have less freedom of breathing than one in whom that cartilage is semi-erect. In all pulmonary affections individuals with pendent epiglottis are at a disadvantage as compared with those in which it has the normal position.

But there are other variations in the larynx of an important kind, namely, those which occur between different peoples. This subject has not received systematic investigation, but Sir G. Duncan Gibb has pointed out that the larynx of the negro presents essential points of difference from those of the white man, by which term he probably means Europeans. Since there is a difference between the phonating organs of the two above mentioned sections of humanity it may be expected that there is considerable diversity in those of humanity in general. The shape of the larynx as seen from above varies according to the activity of breathing and the sound which is being produced. In the white man the outline as defined by the base of the epiglottis, the cricoid cartilage, and the arytenoid cartilages is semicircular, and the hindmost margin is broadly rotund. In the black man the shape is much more elliptic, the hinder portion being narrower than any other part. At the back part of this outline are two reniform bodies which form the summit of the arytenoid cartilages, and are specially termed the tubercles of Santorini. These are invariably present in the normal larynges of all men. Between these and the epiglottis the cuneiform bodies or cartilages of Wrisberg are situated when present. They are frequently entirely absent in the white man, are present in a rudimentary condition in some, but are very rarely conspicuous. In the black man, on the other hand, they are seldom if ever absent, and are, in the great majority of instances, well developed. Sir G. D. Gibb describes them as small adipose masses of the size of peas, and urges that the presence or absence of these cartilages would alone suffice to distinguish the larynges of the two groups of mankind. In the central portion of the laryngeal area there are the vocal cords proper, then, external to these, and on a somewhat higher level, the aperture of a space which separates each true from each false vocal cord. This space is the ventricle of Morgagni. In the white man the vocal cords have their broad surfaces horizontal, whereas in the black man they shelve or dip outwards; the angle of dip varying in individuals, but always well-marked. The ventricles in the white man have their floors nearly or quite on a level with the vocal cords, and project horizontally or slightly upwards in an outward direction. Hence when the larynx is looked at from above, their apertures are barely visible, appearing only as a narrow dark line. In the black man these cavities project downwards at a high angle, so that the large proportion of them is situated below the level of the vocal cord. Owing to the oblique disposition of both the cords and the ventricles a view from above enables one to look right into the cavities. As these cavities are bounded by the thyro-arytenoid muscles these muscles must necessarily be differently disposed relatively to other parts of the larynx in the white than in the black man.

The Santorinian and Wrisbergian cartilages occur in many of the vertebrate orders. In the *Quadrumana* they are usually present, but in most platyrhines they are coalesced into one mass, whereas in most catarhines they are distinct. In some of the loud-voiced monkeys the laryngeal ventricles are more highly developed and more numerous than in man. The male gorilla has very large cavities, and, as is well known, his voice resounds for immense distances through its native forests; the *Mycetes* have exceedingly voluminous cavities diverging from the sides of the larynx and pharynx, and, as Owen remarks, "travellers in the forests of tropical America testify to the astounding tones emitted by these far-heard 'howling' monkeys." In the cats, horses, bears, and other families, the Santorinian and Wrisbergian cartilages are developed in various degrees, and in many the laryngeal sacs or ventricles are large. The loud-roaring lion, the resounding ass, the neighing horse, and other strong-voiced creatures, have deep ventricles; while the feeble-voiced sloths, whales, &c., have those cavities very shallow; while the mute armadillos have no ventricles at all.

The assiduous use of the laryngoscope of late years has enabled observers to familiarise themselves with the variations in the structure of the larynx, and with the changes of position which its various visible parts undergo during the production of sounds. These researches have been principally carried on by Czermak, Garcia, and Gibb. As a sequel to the observations of Müller and Magendie [E. C. vol. iii. col. 354], we give Dr. Carpenter's summary of what Czermak has ascertained. "The appearances which present themselves when the interior of the larynx is examined during life are, according to Professor Czermak, that in the almost semilunar space bounded by the posterior wall of the pharynx, and the base of the tongue, the upper curved free edge of the epiglottis is seen, its lateral portions just touching the posterior pharyngeal wall, and its central portion arching forwards, so as to leave an interval for the passage of air in the median line. Near the centre of the cleft, between the upper border of the epiglottis and the wall of the pharynx, a transverse band or cushion is also seen, of a reddish colour, and formed by the edge of the fold of mucous membrane sustained between the two separated arytenoid cartilages. The anterior outline of the fold is concave in front, and forms, with the superior border of the epiglottis, which is concave behind, and situated a little higher, a narrow transversely elliptical fissure. If the vowel *a* be now sounded as in *ah* or *eh*, the semilunar space behind the base of the tongue is enlarged, the epiglottis rises and separates from the posterior wall of the pharynx, the glottis becomes widely opened, and a considerable portion of the anterior wall of the trachea can be perceived. A small rounded swelling, situated to the outer side of the tubercles of Santorini, which was previously concealed by the lateral border of the epiglottis, now also comes into view. The movements of the arytenoid cartilages during the production of vocal sounds can be very distinctly observed by the laryngoscope; and the account given by Professor Czermak possesses considerable interest, since it fully corroborates the views derived from theory and experiment on the dead subject, which had been expressed before the introduction of the instrument. As soon as we wish to utter a sound, the two arytenoid cartilages raise themselves in the fold of mucous membrane which covers them, and approach one another with surprising mobility. This movement effects the approximation of the vocal cords, and consequently the constriction of the glottis. The study of the mode of the gravest chest sounds is extremely difficult on account of the arytenoid cartilages becoming elevated, and rapidly approaching one another, until they come almost into complete contact, whilst they bend under the depressed epiglottis in such a manner, that the latter, as viewed by the laryngoscope, entirely conceals the interior of the larynx. During the emission of the most acute sounds the glottis is contracted in a linear form; on each side we perceive the vocal cords distinguished by their whitish-yellow colour, and a little to the outer side is a narrow groove indicating the position of the ventricles of Morgagni. Farther outwards again are the false or superior vocal cords. These parts, with the erected arytenoid cartilages, the epiglottis pulled upwards and forwards, and the aryteno-epiglottidean ligaments, together form a short and stiff tube situated above the glottis; the whole appearing, from the sensations we experience during the experiment, to be in a state of very great tension." Garcia's explanation of the falsetto voice is similar to that offered by Müller, viz., that in the production of the chest notes the parts are of low tension, and the ligaments vibrate throughout; whereas when the high falsetto notes are produced a portion only of the vocal ligaments are vibrated. The number of vibrations per second varies from 80 to 999. The average length of each cord in males is ·73 inch when at rest, and ·93 inch when most extended; while the range in females is from ·51 to ·63 inch. The extreme delicacy of the organ, and the perfect control which a practised singer has over it, is manifest from Madame Mara's case. The compass of her voice was three octaves, or 21 tones. Between each tone she could sound at will 100 distinct intervals. As each interval corresponds to a definite length of the vocal cords, she was able to give each cord any one of 2100 lengths at discretion. As the length varied only by one-eighth of an inch, the difference between any two intervals corresponded to an extension or contraction of rather less than the seventeen-thousandth part of an inch. Dr. Carpenter urges that the utterance of sounds is essentially an instinctive action, since no note can be produced at will unless the mind can recall the kind of effort formerly required to indicate that note when sounded, or unless the note is produced at the time, and the correct position ascertained by experimental efforts. His position may be exemplified thus:—A deaf man might know that a certain sound was produced by vibrating his vocal cords a certain number of times per minute; and he might also know what should be the length of his cords, and what their degree of tension, in order to make them vibrate at this speed when a current of air is expelled through the glottis. Such a man, we think Dr. Carpenter would say, would be incapable of emitting that note at will. Some experiments made by Dr. Gibb, however, indicate that the will has considerable control over all parts of the larynx, at least in some individuals; and that to a far greater extent than is usually supposed. Thus, he says that "if he deeply inspires, and forcibly or strongly draws in the air, the glottis is seen widely open, the thyro-arytenoid muscles and vocal cords are drawn laterally outwards, and under favourable circumstances the trachea can be seen throughout its entire length, permitting of a view of its bifurcation and commencement of the bronchial tubes. This act is accomplished during breathing by the action of the posterior crico-arytenoid muscles. If, on the other hand, the breathing is arrested for a few moments, and the action of the little muscles excited by the will, there is seen a remarkable phenomenon, which consists in the opening and shutting of the glottis with extreme rapidity in the same manner as the blades of a pair of scissors. The glottis may be retained of a triangular shape, perfectly motionless, or kept quite shut, the edges remaining in contact at pleasure. So complete is the control over the laryngeal muscles in the author, that the balance of contraction and relaxation of the fibres may be so accurately regulated as to retain the glottis of any form, size, or width, at will, for some seconds, without an inspiration. When the lips of the glottis are in contact, and so retained, the pressure is such during the muscular contraction, that the fibres of the aryteno-epiglottic or Hilton's muscle are set in action, and the epiglottis is drawn downwards, and to some extent conceals the glottis. This last phenomenon further proves the voluntary power possessed over a set of fibres which were considered as the least likely to be under the control of the will, for their action was called spasmodic or convulsive, which permitted of the rapid passage of the food over the glottis and its precipitation into the œsophagus." Dr. Gibb considers it probable that in all persons true voluntary power is possessed over the laryngeal muscles, and "to such an extent that the glottis may be closed with a distinctly flapping noise, chiefly by the powerful and rapid contractions of the thyro-arytenoid muscles and their co-ordinate assistants, but especially the crico-thyroid, which, equally with the thyro-arytenoid, regulate the tension, position, and vibrating lengths of the vocal cords."

(Owen, *On the Anatomy of Vertebrates*; Carpenter, *Principles of Human Physiology*, Sixth Edition; Gibb, *Report of the Thirty-third Meeting of the British Association for the Advancement of Science*, p. 115; as also his *Published Works*, reprinted for private circulation).

LAURENTIAN FORMATION. The geologists of Canada have given this name to the series of stratified rocks which underlie the Potsdam sandstone in North America, and which are consequently older than this sandstone, which belongs to the highest portion of the Cambrian formation. The name has been extended to other rocks occurring in Scotland and various parts of Europe, which are supposed to be of the same age, partly from their position with respect to other rocks of known age, and partly from the peculiarities in their mineralogical constitution.

They are the oldest rocks known, and according to Dana, they form the substratum upon which all the newer rocks repose. This, however, is probably saying more than the facts before us fairly warrant. But if they are not of universal occurrence, they certainly range over very wide areas, and probably appear at the ridges of a series of gigantic folds. Thus we find them in Bohemia, and proceeding westward of a north and south line drawn through that country, they occur in Norway and Sweden; in Charnwood Forest (probably), or about the centre of England; the west side of Scotland and the Malvern Hills (possibly); the promontory of St. David's (possibly); and, csossing the Atlantic, again in North America.

In this last country they occur as surface rocks over an area of about 200,000 square miles, the great proportion of which is situated to the north of the St. Lawrence river and the chain of lakes connected with it. Their thickness is estimated by Sir W. Logan at upwards of 30,000 feet, or about five geographical miles, and the corresponding rocks in Bavaria are estimated by M. Gümbel to be 90,000 feet thick. Although much confidence cannot be placed in these rough estimates, it may be useful to compare them with the thicknesses assigned to the higher and more richly fossiliferous formations. The Silurian formation is about 5 miles thick; the Devonian, Carboniferous, and Permian together are about 4½ miles thick; and all the rocks above the Permian do not exceed 4½ miles. If, then, we take Logan's estimate, the whole thickness of strata known to geologists is 19 miles, of which the Laurentian occupies more than one-fourth.

In this vast accumulation of matter there is buried the evidence of events which occurred at a very early period in the history of the globe; but not the earliest, for there are numerous facts which indicate an antecedent period.

On examining the 30,000 feet of rock in Canada, it has been found convenient to divide it into two portions, viz., the Lower Laurentian and the Upper Laurentian, or Labrador Series; while above them come another group of rocks, viz., the Huronian Series, which will be most conveniently noticed here.

The Lower Laurentian is about 18,000 feet thick, and is composed of a reddish gneiss, hornblendic, and micaceous schists, quartzite, and limestones, which alternate one with another in the same way as the quartzose, aluminous, and calcareous strata of more recent formation; but instead of being arranged in horizontal strata they are everywhere bent into numerous parallel folds. In many places the stratified disposition of the materials is clearly shown, more particularly where beds of iron ore exist. Some of these beds are 100 feet thick, and are banded with layers of quartz rocks, gneiss, and schists, which strongly resemble the grouping of sandstone, shale and iron ore in the formations, which are universally admitted to be sedimentary. The difference between the two cases is that the older Laurentian materials have been subjected to the greater alteration, so that what were once beds of sand have become hardened and crystallized quartzite; what were beds of soft mud and clay have become gneiss and schist; and what was once a calcareous ooze has become a crystalline limestone; and in each case the original sedimentary aspect has been almost entirely obliterated. These statements are not conjectures, but are capable of direct proof. These old rocks are composed of finely divided matter, which has doubtless been formed from massive rocks by the degradation of some older land by atmospheric and marine agencies; and in their original condition, as sediment, formed beds which were spread horizontally over large areas by currents and waves. From this it may be inferred that in the Laurentian period the moon exercised its influence in promoting tidal action, and the sun its influence in creating winds, which almost necessarily imply rain and diversity of climate. But before the Upper Laurentian was deposited the horizontal beds of the Lower Laurentian were not only folded and curved, but the tops of these folds had been planed down or denuded. This is the earliest example known of a common geological phenomenon, and the probability is that it was effected in the same way, viz., by the levelling action of the sea on dry land. This deposition of a series of beds unconformably upon an older series of beds constitutes what geologists term a *break* in the succession of strata, and always indicates the lapse of an amount of time at least equivalent to that required to effect the denudation. The materials thus removed are either deposited somewhere else to form beds intermediate between the Upper and Lower Laurentian series in age, or they have been deposited and have again been swept away to enter into the construction of beds of more recent formation.

The Upper Laurentian is more than 10,000 feet thick, and consists of crystalline rocks, which are mainly composed of felspars, different from the orthoclase which chiefly prevails in the older gneiss. The most characteristic of them are the labradorite and hypersthene rocks. The distinct character of the rocks of the two periods is remarkable, and is well shown by Dr. Sterry Hunt, in a paper referred to at the end of this article.

In the Lower Laurentian Series the clays which contained but little alumina when deposited, have been metamorphosed into granitoid gneiss. The felspar is frequently a nearly pure potash felspar, but it sometimes contains a large proportion of soda. Mica is almost entirely wanting, and is never abundant in large masses of this gneiss, although small bands of mica schist are occasionally met with. Argillites (which abound in potash and silica) appear to be absent in this series, nor is there any rock which seems likely to have been derived from them. Chloritic and chiastolite schists and kyanite are probably wanting, or are, at any rate, extremely rare. The aluminous deposits containing an excess of alumina are represented by diabase, made of dark green pyroxene and bluish labradorite, often associated with red aluminiferous garnet, which latter material often forms small beds. These basic aluminous minerals form an insignificant proportion of the rock. This series of rocks is also remarkable for the small amount of ferruginous matter diffused through its strata, from which the greater part of the iron seems to have been removed and accumulated in immense beds of hæmatite and magnetic iron. Beds of pure plumbago also characterise this series, and are generally found in limestones. They are here developed to an extent unknown in more recent strata, and are associated with beds of apatite which sometimes have a thickness of several feet. The serpentines of this series are generally pale in colour, contain much water, little iron, and no chrome or nickel.

The Upper Laurentian Series is characterized by great beds mainly composed of the triclinic felspars, and more especially those which contain the smaller proportion of silicic acid, such as anorthite and labradorite. They sometimes form mountain masses almost without admixture, but at other times they contain a little pyroxene. Beds of hypersthenite, and of rocks resembling hyperite and diabase also occur in this series. Their structure is generally granitoid, but is often compact; their colour is grayish, greenish, or bluish, except on the weathered surfaces, which are usually white. The opalescent labradorite rock of Labrador is perhaps the most characteristic of this group; it often contains small quantities of red garnet and brown mica, and more rarely quartz and epidote. Magnetic iron and ilmenite is disseminated through these rocks, and here and there form beds of considerable size. These felspar rocks, or *anorthosites*, as they are sometimes termed, make up the great bulk of the series; but they are associated with beds of quartzose orthoclase gneiss and crystalline limestones, which we have seen are abundantly developed in the Lower Laurentian Series.

As the Upper Laurentian rocks have been derived from the waste of some still older land, and as their composition as a whole differs so widely from that of the Lower Laurentian rocks, it seems probable that the materials forming them have been derived from different areas; and that in the one area the richly silicated felspars, such as orthoclase, predominated; while in the other feebly silicated felspars, such as labradorite, were most prevalent. It therefore appears to us more probable that the Laurentian, or Fundamental, gneiss represents a portion only of a variously constituted earth rather than the first solidified stratum of the earth's crust.

The third group of rocks, or the Huronian Series, rests unconformably upon the folded and denuded Upper Laurentian rocks; and this forms another *break* in the succession of strata. It occupies an area upwards of 700 miles in length on the south-east and north-west sides of Lake Superior, and is probably largely developed in Norway and other parts of Europe. In North America its thickness is about 18,000 feet. The most abundant rocks are quartzite and chloritic slates with which are interstratified several bands of crystalline limestone, mica schist, diorite, granite, and gneiss. It is remarkable for the great abundance of its conglomerates, which frequently contain pebbles (such as red jasper) and boulders derived from the gneiss and other crystalline rocks of the Laurentian Series. Its unconformability to the Laurentian rocks is not universal, for it has been observed to rest conformably upon them in several localities: as for instance near Fort William on the north shore of Lake Superior; at the lower end of the Second Portage above the Grand Falls; and at Dovrefield in Norway, and in other European and American localities. But the most striking feature of the Huronian group (if we except its conglomerates) is the remarkable abundance of metalliferous ores which it contains. The great ferriferous beds and mountains of Dannemora and Gellivara in Sweden; at Marquette in Michigan; and probably those of Missouri, are assigned to this series; as also the copper-bearing beds around Lake Superior. Dr. Bigsby ('Q. J. Geol. Soc.,' vol. xix. p. 45) has endeavoured to show that the Huronian Series forms an older geological group than the Cambrian.

The principle characteristics of the rocks above-mentioned are thus concisely stated by Dana ('Manual of Geol.,' p. 139): (1.) The azoic rocks are nearly all crystalline rocks, a few sandstones, slates, and conglomerates are the only exceptions; and these are excessively hard rocks. (2.) The crystalline rocks are remarkable for the small amount of silica they contain (a fact noticed by T. S. Hunt). This is seen in the absence of quartz from many of the rocks (the diorite, Labrador rock, hyperite), and the abundance of felspars, like labradorite, that have a low proportion of silica. (3.) The prevalence of iron is another characteristic. This is seen in the abundance of the minerals (silicates) containing iron, as hornblende, hypersthene, chlorite, garnet; also the reddish colour of much of the felspar; also the beds of iron ore, which exceed in extent those of any other age. (4.) There are none of the simple silicates of alumina.

The time that was occupied in building up, or rather re-arranging from older materials miles of strata, must have been considerable; and it may be asked whether it was all required for preparing the world for living creatures, or is there any evidence that life had already appeared? There is strong presumptive evidence that life had commenced before the end of the Lower Laurentian. In 1858 Mr. McCulloch found in one of the bands of limestone certain concentric markings which resembled those of *Stromatopora*, but few persons were at that time disposed to believe they were fossils. Some years afterwards a number of other specimens were obtained, also from Lower Laurentian limestones, which were pronounced to be *Foraminifera* of a high grade of organization, and named by Dr. Dawson *Eozoon Canadense*. This view has also been supported by Dr. Carpenter. The evidence in support of this opinion will be found in full in papers by those gentlemen in the 21st and 23rd vols. of the 'Quart. Journ. of the Geological Society.' These announcements led to the discovery of similar specimens in the Laurentian rocks of Europe. According to Professors King and Rowney, the appearances in all these specimens are not due to the former existence of *Foraminifera*, but are simply the results of a peculiar aggregation of certain minerals ('Q. J. Geol. Soc.,' xxii. p. 185; xxv, p. 115). In the same volumes will be found Dr. Carpenter's reply to the objections raised against the foraminiferal origin of these appearances. The result of the discussion appears to be in favour of the eozoonal rock having been largely composed of the fragmentary remains of a rhizopodous shell. [FORAMINIFERA, E. C. S.] But setting aside the case of the Eozoon it is not improbable that the graphite and anthracite found in the Laurentian rocks have been formed from vegetable remains. Amongst other supposed indications of life contemporary with the formation of the eozoonal limestone are rotund perforations which have been filled up with rounded sand more or less stained with ferruginous and carbonaceous matters, more especially at the outer margin.

(Logan, *Geology of Canada*, 1863; Hunt, in *Geology of Canada*, 1863; Logan, *Q. J. Geol. Soc.*, xxi. p. 45; Bigsby, *Q. J. Geol. Soc.*, xix. p. 36; Murchison, *Q. J. Geol. Soc.*, xix. p. 354; Murchison, *Siluria*, 4th edition.)

LEMURIDÆ [E. C. vol. iii. cols. 381—392; CHEIROMYS, E. C., vol. i. cols. 957, 958; LICHANOTUS, E. C., vol. iii. cols. 423, 424]. Numerous contributions have recently been given to the scientific world which have thrown more or less light upon the structure of this remarkable group and the place which it occupies in the general plan of creation. Still the classification proposed appears to us to be in many instances only tentative efforts to represent the truth, rather than the final attainment of that end. The definition of groups and genera seem to depend too much upon a few prominent osseous and external characters; they have, in our opinion, too much of mere description and too little infusion of that spirit which feels that every creature is a wonderfully contrived machine, adapted for particular purposes, and whose structure varies with those purposes.

In 1851 Geoffroy divided the Lemuroid animals into three families, viz., the *Lemuridæ*, *Tarsidæ*, and *Cheiromyidæ*; and the family *Lemuridæ* was itself divided into three sub-families, according to the number of the teeth, thus :—

I. *Indrisina.* Grinders, $\frac{5—5}{5—5}$; lower cutting teeth, 2 ; or 30 altogether. This includes the genera *Indris, Propithecus,* and *Avahis.*

II. *Lemurina.* Grinders, $\frac{6—6}{6—6}$; lower cutting teeth, 4 ; or 36 altogether.

Tarsus moderate, or of the usual length. It includes the genera *Lemur, Hapalemur, Lepilemur, Cheirogaleus, Perodicticus, Nycticebus,* and *Loris.*

III. *Galagina.* Grinders, $\frac{6—6}{6—6}$; lower cutting teeth, 4 ; or 36 in all. Tarsus elongate. Genera : *Microcebus* and *Galago.*

The classification of Dahlborn has much resemblance to the foregoing, although that zoologist relies principally upon the comparative length of the tarsus and metatarsus. He recognises three groups, viz. :—

I. The *Prosimiæ brachytarsæ,* or those forms which have the tarsi shorter than the metatarsi. Genera : *Indris, Avahis,* and *Propithecus.*

II. The *Prosimiæ isotarsæ,* in which the tarsi and metatarsi are of equal length. Genera : *Perodicticus, Nycticebus, Loris, Lemur, Lepilemur,* and *Cheirogaleus.*

III. The *Prosimiæ macrotarsæ,* with the tarsi much larger than the metatarsi. Genera : *Galago, Hemigalago, Microcebus,* and *Tarsius.* The first two groups are combined to form the family *Lemuridæ,* which is consequently almost co-extensive with Geoffroy's group of the same name. The last group is separated to form a distinct family, and *Cheiromys* is the type of a third family, the *Glirisimiæ.*

In both these classifications there is a triple division of the lemuroid animals into families. In both the great majority of the genera are placed in one family, the *Lemuridæ.* The *Tarsidæ* of Geoffroy, embraces but one genus, *Tarsius* ; but Dahlborn associates with it the genera which Geoffroy places in his sub-family, *Galagina.* In both a family is constituted for the peculiar genus, *Cheiromys ;* Geoffroy calls it *Cheiromyidæ,* and Dahlborn *Glirisimiæ.*

Dr. J. E. Gray's classification, which we append, is very similar to Geoffroy's in its main features ; but he includes the *Galeopitheoidæ* amongst the Lemuroids, of which they form a fourth family.

Family I.—LEMURIDÆ.

Cutting teeth, $\frac{2—2}{6}$ or $\frac{1—1}{4}$; the upper far apart ; the lower compressed, shelving forward ; the two outer larger, opposed to the space between the upper cutting teeth. The fingers and toes free, well-developed ; the first hind-toe shorter, with an elongate curved claw.

I. The head elongate ; face developed ; eyes moderate ; hind-legs elongate ; fingers well developed, normal.

* Teeth 30 ; hind-foot very short ; great toe long. *Indrisina.*
1. *Indris.* Tail none.
2. *Propithecus.* Tail elongate.
** Teeth 36 ; tail elongate ; great toe broad. *Lemurina.*
a. Feet short ; ears moderate.
3. *Varecia.* Head surrounded by a ruff ; ears tufted.
4. *Lemur.* Head without any ruff ; wrist with a narrow bold line and pad above.
5. *Prosimia.* Head without any ruff ; ears externally hairy; wrist hairy.
b. Teeth elongate ; ears large.
6. *Otogale.*

II. Head short ; face short, tapering ; eyes (and orbits) very large.

* Hind-legs elongate ; tail elongate.
† Teeth 30 ; feet, short, broad. *Microrhynchina.*
7. *Microrhynchus.*
†† Teeth 36 ; feet short, broad. *Galagonina.*
8. *Hapalemur.* Ears moderate ; upper cutting teeth on the inside of canine.
9. *Cheirogaleus.* Ears moderate ; upper cutting teeth in an arched series.
10. *Lepilemur.* Ears large, elongate ; upper cutting teeth in an arched series. Tail with close-set, short hair.
11. *Callotus.* Ears very large, contractile. Tail with bushy hairs.
††† Teeth 36 ; feet elongate, slender.
12. *Galago.*
** Fore and hind-feet equal ; tail none, feet short.
† The hands normal ; fingers free ; index clawed. *Lorisina.*
13. *Nycticebus.* Limbs short.
14. *Loris.* Limbs elongate ; slender.
†† Hands broad, short ; index finger abortive ; clawless. *Perodicticina.*
15. *Perodicticus.*
16. *Arctocebus.*

Family II.—TARSIDÆ.

Cutting teeth, $\frac{4}{2}$, erect, cylindrical, conical ; the two upper front ones elongate, acute ; the lower ascending obliquely, crowded between the canines; grinders, $\frac{6—6}{6—6}$. The fingers and toes free, well developed ; the first and second hind-toes shorter, each with an elongate curved claw. Head short. Eyes and orbits very large. Limbs free, elongate. Foot very long, as long as the shin. Tail elongate, hairy.

17. *Tarsius.*

Family III.—DAUBENTONIADÆ.

Cutting teeth, $\frac{2}{2}$, compressed, large ; canines none ; grinders, $\frac{4—4}{3—3}$. Limbs free. The fingers and toes well developed. The fingers very long and slender. The great toe broad. The index finger with a long curved claw. Face short. Tail elongate, hairy.

18. *Daubentonia,* Geoffroy. Syn. *Cheiromys,* Cuvier.

Family IV.—GALEOPITHECIDÆ.

Cutting teeth, $\frac{4}{3}$. The upper middle small, side one compressed ; lower shelving, pectinate ; canines, $\frac{1—1}{1—1}$, like the molars ; grinders, $\frac{5—5}{5—5}$. Limbs and tail united by a membrane covered with fur. Limbs short, sub-equal. Fingers and toes short, sub-equal, compressed, united by a membrane.

19. *Galeopithecus.*

Mr. St. George Mivart's classification is thus given by him in the Proceedings of the Zoological Society for 1864 and 1867 :—

SUB-ORDER, LEMUROIDEA.

Family I. LEMURIDÆ.

Sub-family 1. *Indrisinæ.*—Incisors, $\frac{2—2}{2}$; canines, $\frac{1—1}{1—1}$; premolars, $\frac{2—2}{2—2}$; molars, $\frac{3—3}{3—3}$ = 30.

It includes the genera *Indris, Propithecus,* and *Microrhynchus.*

Sub-family 2. *Lemurinæ.*—Incisors, $\frac{2—2}{4}$ (except in *Lepilemur,* in which there are none in the upper jaw) ; canines, $\frac{1—1}{1—1}$; premolars, $\frac{3—3}{3—3}$; molars, $\frac{3—3}{3—3}$. Tarsus short, or with the cuboid and naviculare subequal in length ; hind limbs considerably longer than the fore limbs ; tail at least equalling two-thirds the length of the body ; mastoidal region of the periotic not inflated (?) ; dorsal and lumbar vertebræ together never exceeding twenty ; gall-bladder with its base turned towards the back.

In this sub-family are included the genera *Lemur, Hapalemur, Microcebus, Cheirogaleus,* and *Lepilemur.*

Sub-family 3. *Nycticebinæ.*—Incisors, $\frac{2—2}{4}$; canines, $\frac{1—1}{1—1}$; premolars, $\frac{3—3}{3—3}$; and molars, $\frac{3—3}{3—3}$. Fore and hind limbs subequal in length ; tail short (always shorter than half the length of the body), rudimentary, or absent ; tarsus short ; third upper premolar with only one large external cusp, and considerably smaller than the first upper molar ; an oblique ridge to the upper molars ; first upper premolar more or less exceeding the second in vertical extent ; mastoidal region of periotic inflated ; one opening representing both the sphenoidal fissure and the foramen rotundus ; carotid foramen conspicuous ; dorsal vertebræ always fourteen or more ; lumbar vertebræ always seven or more ; gall-bladder, with its fundus, not turned towards the back.

It embraces the genera *Nycticebus*, *Loris*, *Perodicticus*, and *Arctocebus*.

Sub-family 4. *Galagininæ*.—Incisors, $\frac{2-2}{4}$; canines, $\frac{1-1}{1-1}$; premolars, $\frac{3-3}{3-3}$; molars, $\frac{3-3}{3-3}$. Upper incisors subequal; first upper premolar longer than the second; third upper premolar with two large external cusps, and about equalling the first molar in size; upper molar with the oblique ridge: postero-internal cusp of second and third molars well developed; hind limbs much longer than the fore; tarsus very long; calcaneum more than one-third the length of the tibia; naviculare much longer than the cuboid; ears very large; tail-longer than the body; mastoidal region of periotic inflated; no interparietal; carotid foramen conspicuous in the basis cranii; one opening representing both foramen rotundus and sphenoidal fissure; dorsal vertebræ thirteen; lumbar vertebræ six; gall-bladder with its base not turned towards the back.

This includes *Galago*, with its sub-genus *Otolemur*, *Otogale*, *Otolicnus*, and *Hemigalago*.

In addition to these he has the families *Tarsidæ* and *Cheiromyidæ*, each with its single representative genus. In connection with the above classification, we will append his condensed remarks on the axial skeleton of the sub-order, and the relation between the Lemuroids and the Anthropoids.

The lemuroids are in marked contrast to the anthropoids, on account of their great variety of structure. The transverse processes of the atlas almost always have their extremities inclined ventrally, and very often the atlas has but one posterior articular surface, the two posterior zygapophyses uniting in the middle line. The transverse process of the fifth cervical vertebra is sometimes simple, and does not bifurcate. The transverse process of all the cervical vertebræ project more sharply backwards than in the *Anthropoidæ*. The ribs are never so few as eleven pairs, while they are occasionally as many as sixteen pairs. There are sometimes as many as nine lumbar vertebræ. The increase in breadth and length of the posterior as compared with the anterior dorsal vertebræ is very slight. Sometimes the third, fourth, fifth and sixth cervical vertebræ are quite destitute of neural spines. The cervical vertebræ are often very much extended antero-posteriorly. The sternum is never formed of so few as two or three bones in the adult; and the first three caudal vertebræ are short. Except in the *Nycticebinæ* the atlas is furnished with wide and long transverse processes; there are, with the same exception, never more than thirteen pairs of ribs, but (except in *Indris*) always hypapophyses and more or less complete chevron bones, and, as in the *Anthropoidea*, the neurapophyses are not perforated by the spinal nerves.

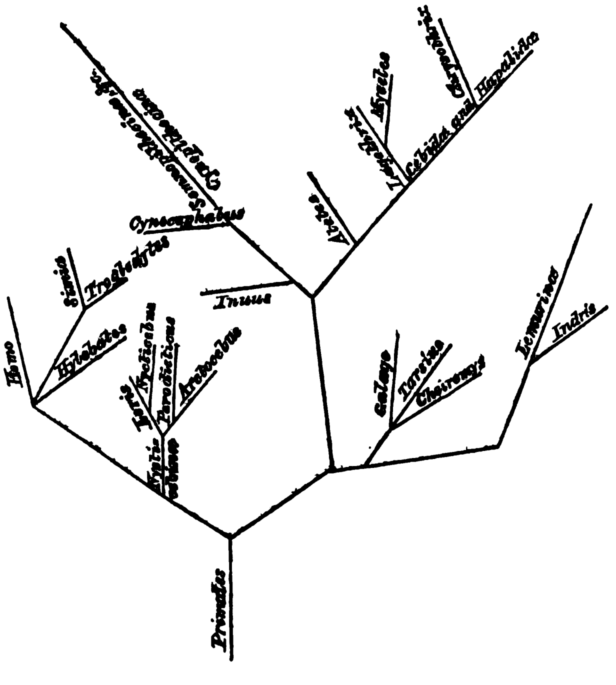
The *Nycticebinæ* contains several aberrants whose vertebral structure has several points which remind one of the same parts in man and the higher apes. The atlas has less extended transverse processes than in the other *Lemuridæ*, and sometimes two articular surfaces for junction with the axis; spine of axis bifid or trifid; transverse process of the third cervical vertebra always, those of the fourth and fifth cervicals sometimes, bifurcated; cervical vertebræ very short, and therefore quite unlike those of *Lemur* and *Indris*; dorsal and lumbar spine all inclined backwards, but sometimes the latter are inclined slightly forwards; increase in length and breadth of dorsal vertebræ backwards very slight; metapophyses mostly inconspicuous but sometimes developed in the cervical region; anapophyses but little developed; sacrum long and tapering posteriorly; caudal vertebræ few, no caudal hypapophyses; increase in length of the lumbar vertebral bodies as compared with the dorsal at its minimum; neurapophyses sometimes directly perforated by the spinal nerves; ribs from fourteen to sixteen pairs; dorsal region relatively much extended, cervical region very little so.

In the *Galaginæ* the atlas has only one articular surface behind; the axis has a simple or bifurcated spinous process; the spines of all the cervical vertebræ posterior to the axis are almost or quite obsolete; there are thirteen dorsal and six lumbar vertebræ; the twelfth or thirteenth dorsal spine is turned forwards; the metapophyses and anapophyses are distinct; hyperapophyses at their maximum in lumbar region; the first dorsal spine long.

In the *Tarsidæ* the cervical spines are almost obsolete; the first dorsal spine very small; the lumbar apophyses very faintly marked; the metapophyses more distinct in the first three caudals than in all the rest of the spine; and the hyperapophyses are absent.

In the *Cheiromyidæ* the atlas has two distinct articular surfaces for junction with the axis; the spines of the third, fourth, fifth, sixth, and seventh cervical vertebræ are almost obsolete; the thirteenth dorsal spine is turned forwards; a process like a second anapophysis occurs in some lumbar vertebræ; the transverse process of the fourth cervical vertebræ bifurcates. There are nine pairs of true ribs; two sacral vertebræ; no hyperapophyses; and no distinct metapophyses or anapophyses in the cervical region.

Mr. Mivart thus sums up his ideas of the classification of the *Primates*, which present us (as regards their vertebral column only) with four principal types of structure, well represented respectively by (1) *Simia*, (2) *Cercopithecus*, (3) *Nycticebus*, and (4) *Lemur*,—the first having, however, many parts in common with the third, and the second with the fourth; so that the affinities between the various groups of the order (as regards their spinal character) may be represented under the symbol of a tree. The trunk of such a tree (see diagram) divides into two main branches—one of them representing the forms possessing few caudal vertebræ, an elongated tapering sacrum, inconspicuous metapophyses or anapophyses, several spines of trunk nearly always vertical or backwardly inclined, and that of the axis more or less bifid or trifid, cervical vertebræ short, and cervical spines sometimes very produced, that is to say, the forms included in the family *Hominidæ* and in the sub-families *Simiinæ* and *Nycticebinæ*; the other main branch representing all the rest of the order, and possessing the characters attributed above to the *Simiidæ* (other than the *Simiinæ*), the *Cebidæ*, the *Hapalidæ*, and the *Lemuroidea* in common. The first main branch gives off a secondary one to represent the *Nycticebinæ*, and this divides into three others for (1) *Homo*, (2) *Troglodytes* and *Simia*, and (3) *Hylobates*. The second main branch bifurcates, its first division representing the *Simiidæ*, other than the *Simiinæ*, together with the *Cebidæ* and *Hapalidæ*; its second denoting the *Lemuroidea* other than the *Nycticebinæ*. From both the *Semnopithecinæ* and *Cynopithecinæ*, *Inuus* and *Cynocephalus* distinguish themselves as separate twigs; and *Ateles* diverges from the *Cebidæ* generally, and very interestingly parallels *Hylobates* in its long cervical neural laminæ, backwardly inclined neural spines of trunk vertebræ, large transverse diameter of thorax, and slightly marked metapophyses and anapophyses; *Mycetes* and *Lagothrix* also, with their marked hyperapophyses, and *Chrysothrix*, with its undivided caudal transverse processes, are also special forms. The genera *Galago*, *Tarsius*, and *Cheiromys*, with their rudimentary cervical spines, diverge so much from the typical Lemurs that they might almost be represented in a distinct primary division of the second main branch, instead of a subdivision of that bifurcation which culminates in *Lemur*, and which gives off a twig to represent *Indris*—a form, as we have seen, almost, if not quite, as distinct amongst the *Lemuroidea* as *Homo* is amongst the *Anthropoidea*.



LEPTOMERIA. A genus of plants belonging to the order *Santalaceæ*, of which the sandal-wood tree of the East is the best known example. This genera is met with in many parts of Australia, but especially abounds in the neighbourhood of Swan river. Some twenty species have been described, which, like the common broom of England, are tall shrubs, with a profusion of long erect branches bearing spikes of very minute flowers, and few or no leaves. *L. Billardieri* bears greenish red berries, which have a pleasant acid taste, and are used by the colonists for making preserves and in the preparation of acidulous drinks. *L. acerba* also produces a similar fruit, which is used for similar purposes. Hence both the kinds of berries are familiarly known as currants amongst Australian colonists.

(Lindley and Moore, *Treasury of Botany.*)

LIASSIC FORMATION [E. C. vol. iii. cols. 441, 442; OOLITE, E. C. vol. iv. cols. 89, 90]. When the palæozoic period, or that portion of it which is represented by recognisable sedimentary deposits, came to a close, great changes were produced. The main result of these appears to have been to divert the detritus-bearing currents from their original courses, and to elevate the surfaces over which they flowed above the sea-level. In all the localities which have been examined there would seem to have been a long suspension of strata-forming actions. In Europe and many other districts the next beds belong to the mesozoic age, and are usually barren or almost sterile in organic remains, although in places fossils are abundant, varied, and of remarkable character. We refer to the triassic group. Next to these follow a succession of strata, which, when fully developed, may present a thickness of 1500 or 2000 feet. These swarm with organic remains of almost every description, from the lowly *Foraminifera* to the predaceous *Ichthyosaurus* and *Plesiosaurus.* The lower portion of this series comprise the Rhætic or Penarth beds, and the higher the great Liassic formation. The Rhætic beds are of very local development, and were formerly considered to form a portion of the same set of beds with the lias, but are now generally regarded as distinct therefrom as the lias itself is from the lower oolites. In E. C. vol. iv. col. 89, they are described as the lowest beds of the liassic series, but in E. C. S. the supplementary remarks on them are given under RHÆTIC BEDS. The lower lias limestone mentioned in the same paragraph is higher than the Rhætic beds, and belongs to the lias proper.

During the liassic period itself there were numerous fluctuations of sea and land, as manifested partly by the alternation of terrestrial with marine organisms in some of the lower lias strata; partly by the absence of some of the subordinate beds in most localities, and partly by the variation in the nature of the rock material. Amongst the presumptive evidences of the old liassic land may be mentioned those gaps in the strata where liassic beds are partly or entirely absent. In some instances the absence is due to denudation which has swept away the liassic sediments after they were laid down, but in most there is reason to believe no beds were formed owing to the surface having been exposed to subaerial conditions. Dr. Bigsby has collected at random 150 instances of missing sedimentary formations, and in 56 of them, or 37 per cent. of the whole, the lias is unrepresented. These instances include many in which the floor and roof of the gap are either both above or both below the lias, so that the percentage is hardly so instructive as would be one based upon the number of cases in which the lias is absent from the situations where we should expect to find it supposing the deposition to have been continuous, and the accumulations not to have been swept away. However, these data indicate roughly that in the northern hemisphere the proportion of land to water during the liassic period was possibly nearly as two to three. This of course supposes that none of the gaps have been produced by denudation. We will give a few illustrations of these gaps, arranging them approximately according to their geographical order. In Chili, Brazil, and Guiana, palæozoic rocks are overlain by post-pliocene beds, so that there seems to be considerable probability that large portions of South America coincides with liassic land. In New Mexico, Texas, Tennessee, Mississippi, Alabama, Georgia, the carboniferous are superimposed by cretaceous beds, so that here again we find traces of a considerable quantity of liassic land. Further north, as in New Jersey, the cretaceous beds rest on the Laurentian gneiss. In addition to these we may refer to the immense area of palæozoic rocks in North America upon which no signs whatever have been discovered of any mesozoic or tertiary strata. It is hardly credible that if such had existed in any large area in Canada, the Hudson Bay Territories, or Labrador, they should have been entirely swept away. At present then we may regard most of North America as the site of land which existed in the liassic period. In Nova Scotia we apparently approach nearer to the confines of the liassic ocean, for there post-pliocene gravels rest upon triassic deposits. It is remarkable at how few localities the lias is developed in North America. Dana in his 'Manual' does not instance a single spot for certain, but a few true liassic fossils were not long since found in the far west; while oolitic fossils have been obtained from the Arctic regions. Crossing over to Europe we find another large area of Laurentian and Huronian rocks either overlain by post-pliocene deposits or lying bare to the sky. There are patches of post-Laurentian deposits, and these have been extensively denuded, but throughout Norway, Lapland, Sweden, and Finland, or an area some 1300 miles in length and several hundred broad, little or nothing is to be seen of any liassic or post-liassic sediments. Many parts of Scotland, Ireland, and Wales, would seem to have been above the water during the period with which we are dealing. In North Devon a post-pliocene gravel formed of pre-liassic material rests upon carboniferous shales. In parts of Somersetshire, as for instance just north of Frome, the lower oolites abut against carboniferous limestone. A little to the south of Frome, as at Holwell, there are liassic conglomerates which mark the limits of the land and sea of the period at that locality. In Dorsetshire the lower lias contains insect fragments and other indications of the vicinity of land. In Yorkshire, where cretaceous rest upon triassic beds, we appear to be near the margin of the liassic sea. From the insect, plant, and other remains found in the lias of south and central England, and from the generally quiet deposition of the beds, this area would seem to have been an arm of the sea, more or less protected from heavy swells. This is in part borne out by the absence of the lias in Middlesex, Essex, Hainault, Pas de Calais, and Ardennes, where strata newer than the lias rest upon, probably in all, palæozoic rocks. In Manche miocene beds rest on the trias, so that here we again approach the liassic sea, which probably occupied the site of the Channel between north-west France and south-west England. In the Sarthe department the country did not sink below the waters till late in the liassic period, for there the upper lias rests on the upturned edges of the lower Silurian. In the department of Vendée upper greensand overlies palæozoic beds; in Aude eocene rests on similar rocks, so that there seems to have been a general prevalence of liassic land along the west side of France. The sea then lay more towards the east. In the Gard and Drôme departments trias is followed by Oxford clay; but in Corrèze, Lot, and Isère liassic strata are sparingly developed. In the provinces of Cataluna, Guadalquivir, Segovia, Mancha, and Cordoba, there are gaps in which the lias is wholly unrepresented. In Valencia and Aragon beds of this age are found, which may have been continuous with those of northern Italy. In Westphalia cretaceous beds rest on carboniferous schists. In the Grindelwald, Switzerland, oolitic strata are superposed on granitic and other crystalline rocks. In the Aargau we have a series of liassic strata, which much resemble those of Dorsetshire in containing insect remains, and in indicating by their condition the deposition of their materials in a great bay or arm of the sea. Professor Heer says, it was evidently protected by a long promontory or reef of rocks. That land existed not far off, we have already pointed out from stratigraphical evidence, but Professor Heer comes to the same conclusion from palæontological facts. He dwells upon the beautiful preservation and abundance of the land insects. They could not have been drifted far, and they could not have been exposed long. He believes they were washed down by a river, and rapidly buried in the earthy matter which it held in suspension. The lower beds are entirely marine, then follow some with the insect remains, which are again succeeded by exclusively marine beds. From this he infers that the land was rising during the first part of the period occupied by these beds, which belong to the lowest lias, and are 35 feet thick; and that it sank again towards its close. In Savoy oolitic reposes on carboniferous strata. In Hanover, Würtemberg, Austria, and Italy, liassic strata indicate that a large portion of the area was oceanic; and from its direction and position relatively to the land of eastern England, and approximate portions of France and Belgium, may have been continuous with the liassic sea of Yorkshire. In Sardinia a gap between the Silurian and cretaceous bespeaks the presence of land there, but it does not seem to have been of large extent. A similar gap occupies a considerable area in Saxony and northern Bohemia. In Poland oolites rest on carboniferous beds, while throughout Russia and Siberia the place of the lias is usually represented by a gap. From this rapid summary the reader may gather what was the position of large liassic lands in the northern hemisphere. There are materials for a far better sketch, but they are difficult to collect; and geologists rarely attempt to point out what were the contours of the lands and seas of the periods about which they treat.

We will next say a few words respecting the material which was laid down in the older liassic seas. In Antrim, or at the north-east corner of Ireland, we find that the Keuper is immediately succeeded by the chalk some ten or fifteen miles south-west of Belfast. At Colin Glen, five miles south-west of this town, the lower liassic series is well developed, but is accompanied by the underlying Rhaetic beds. The Keuper is succeeded by nearly twenty feet of dark shales, limestones, and sandstones, generally thin bedded, and alternating with one another. The shales predominate, comprising more than seventeen feet; while the limestones do not exceed twenty inches altogether, and are mostly grouped near the upper part of the section. There are a few bands of sandstone, each one or two inches thick. Above these comes the white lias having a thickness of more than twenty-six feet. The lowest ten feet is grey sandy shale, and the remainder marls and limestones. During the period of the deposition of these beds the conditions for the accumulation of calcareous materials were gaining the ascendant, while the finer argillaceous deposits were becoming less prevalent. Judging from these facts, it would seem that Colin Glen was at this time some distance from the shore, and that the district around it was sinking. Above these come the lower lias beds, rather more than 38 feet thick, and composed of limestones, shales, and marls. The limestones form the lowest four feet, whilst marls and shales make up the remaining thirty-four, the shales predominating. In this area, then, the lower lias was deposited under nearly the same bathymetrical conditions as the white lias. It is not unlikely the lias was originally thicker and spread out further westwardly, since it is overlain by cretaceous strata; and there are signs of denudation having occurred before these newer beds were laid down.

Passing into Glamorganshire and Somersetshire the indications of the older liassic shore line are numerous and manifest; and traces even of the fresh water courses of the period are to be detected. The westernmost extension of the lower lias in Great Britain occurs in Glamorganshire and Somersetshire, and in both counties the lowest beds are usually very peculiar in character, consisting largely of hard conglomerates and tough calcareous bands. This character is apparently associated with the circumstance that they rest upon or overlie the carboniferous limestone, which in many places forms a sloping beach or cliff-like surface. From an examination of the area generally, there is little doubt that the carboniferous limestone had been elevated above the sea, and considerably denuded before the triassic period, and that it did not become a bottom of an ocean under circumstances favourable for the preservation of organic remains before triassic and early liassic times, and that since then it has been subjected but slightly, if at all, to oceanic influences. The lowest conglomerates in and around Bridgend, Glamorganshire, consist of materials derived almost entirely from the carboniferous limestone. They are formed sometimes of rolled pebbles of the limestone itself, which must even then have acquired a considerable degree of hardness and toughness, and sometimes of chert. The limestones are sometimes hard and crystalline, and sometimes soft and shelly, while bands of chert occur at intervals. At Southerndown cliff, and generally along the coast, the beds are white at the base, and gradually become darker towards the top. Near the summit argillaceous materials become abundant, giving the limestones through which they are disseminated a dark grey tint, and forming thick intercalated bands of shale. The lower calcareous strata are denominated by Mr. Tawney, the Sutton and the Southerndown series, and are regarded by him as of pre-liassic age; but the general opinion of geologists now is ruled by the researches of Moore and other eminent geologists, who regard them as a peculiar modification of the lower liassic group. At Brocastle, midway between Bridgend and Cowbridge, the carboniferous limestone forms a cliff, on the face of which there occur a conglomerate and a limestone. The conglomerate occupies the upper part of the slope, and rests immediately on the terraced edge of the carboniferous limestone; while the liassic limestone lies above it and occupies the lower part of the slope. The conglomerate has an average thickness of one foot, and the limestone is exposed to a depth of five feet, in which space it comprises several dense irregularly bedded layers, crowded with *Rhynchonella variabilis* and corals. At Langan, a mile and a half north-east of Brocastle, similar deposits have been proved by a shaft sunk for lead-mining. The uppermost beds were regularly bedded dense limestones, with partings of marls, underlain by limestones having the peculiar character of the Sutton stone; which are in their turn underlain by upwards of 150 feet of unstratified conglomerates. To the west of Bridgend the lias is supported by Keuper beds, and there consists of frequent alternations of limestones, marls and clays—there being 476 beds in a little over 300 feet. These beds rarely contain pebbles of carboniferous limestone or of chert, and yield traces only of galena, a mineral which is general in sparing quantities in the beds of Brocastle and Langan. In South Wales the carboniferous limestone is much fissured, and the fissures are filled in with liassic and Rhaetic materials; but as this feature is much better seen in Somersetshire, we shall allude to it again presently. There are no sections in Somersetshire corresponding in lithological peculiarities to those at Brocastle and its vicinity, although we consider it probable such beds may occur on the flanks of the Mendips. The beds at Camerton resemble those to the west of Bridgend in consisting of alternations of limestones (or white and grey lias, as such limestones are called in Somersetshire), clay, and marl; but the whole series is of moderate thickness. The lower lias is, however, particularly well shown in the Camel Hill railway cutting. The Keuper is there 80 feet 6 inches thick, and the Rhaetic beds 38 feet 8 inches. Then follow the white lias in 43 beds, having an aggregate thickness of 23 feet, and consisting almost entirely of marls and white lias (limestones). Above this is the blue or lower lias, of which the visible portion comprises 182 beds having an aggregate thickness of 223 feet 2 inches. The blue lias consists of several subordinate sets of beds. Lowermost are the 'insect and crustacean beds,' which are a succession of finely laminated marls and limestones, characterised by impressions of insects, *Eryon wilmcotensis*, scales of *Lepidotus*, and possibly plants. Then follow the 'Saurian and *Ostrea* beds,' a succession of marls and firestone, with shells of *Ostrea liassica*, *Ammonites planorbis*, &c.,—marls and limestones with marine organisms for some twenty feet more, when blue clays seem to take the place of the marls for about 80 feet; after which blue marls again come in and alternate with 'stone' (probably limestone) up to the summit of the section, which does not seem to be above the horizon of the *Ammonites Bucklandi* zone. Within the Mendip Hills and the area of the Somersetshire coal-field, the triassic, liassic, and oolitic beds are very feebly developed, as though this district had formed a shallow lagoon in the midst of the old secondary ocean. How great the reduction is will be manifest from the following figures given by Mr. Moore, which represent the greatest thickness of the groups of strata indicated outside the coal field, and their least thickness inside it:—

	Without coal basin. Feet.	Within coal basin. Feet.
Triassic beds	2000	50
Rhaetic beds	50	50
Lower lias	700	2
Middle and upper lias	500	42
Inferior oolite	170	25
	3420	169

In Somersetshire, as already mentioned, the carboniferous limestone is traversed by fissures filled with deposits of subsequent ages. In many cases the materials belong to the lower lias, and frequently occur under the most extraordinary conditions. Thus near Frome the fissures, which are not simply cracks, but irregular veins, which sometimes have the appearance of underground caves, have a general east and west trend, and traverse the limestone for long distances, probably miles. Their appearance and character are well seen at the quarries near Holwell, which are opened in the carboniferous limestone. At first sight the excavation and the walls of the quarry appear to exhibit nothing but carboniferous limestone. On further examination it is noticeable that the quarrymen prefer to work a certain vertical course of stone; and their reason for this is that the limestone is of two qualities. By working the serviceable bands only, the bad limestone is left to project out from the sides of the quarries as immense vertical dykes, whose widths vary from a few up to twenty or thirty feet. The width of each dyke varies, and some of the widest can be traced up to mere cracks a few inches wide, through which all the material filling them has been poured. These dykes are formed of liassic limestone, and frequently have a character analogous to mineral veins; indeed some of them are mineral veins in which the principal gangue is crystalline carbonate of lime and the principal ore carbonate of iron. These dykes contain many fossils, which abundantly testify to the geological age of their formation. Examples of this kind are numerous; but perhaps the most interesting is that exhibited at the Charter House lead mine in the highest portion of the Mendip table land. As this mine is now closed, and has probably been examined by one geologist only, we give that geologist's account of it. "The mineral districts comprised in this part of the Mendips and Priddy were extensively worked during the Roman occupation; and the great industry they manifested is shown by the enormous quantity of refuse slags and slimes left by them in some of its valleys. Owing to their imperfect mode of working, about 12½ per cent. of lead remains, which is now being extracted by several companies. In general, the lead ores of this district 'prove' near the surface; and so well and completely did the Romans appear to have exhausted the veins, that little has been subsequently worked profitably. I paid a visit to a shaft which had been sunk as an experiment by one of the companies, but which had lately ceased working, at Charter House Warren. It is situated to the north-west of the highest carboniferous limestone platforms of the Mendips. A mile to the north the old red sandstone, surrounded by the carboniferous limestone shales, is present, the carboniferous limestone itself, both on its north and south flanks, being fringed by the dolomitic conglomerate, beyond which the new red sandstone succeeds. The nearest horizontal deposit of liassic age to the north is at Nempnett, 2½ miles distant, which yields *Pecten Pollux* and *Lima tuberculata*. Two miles to the east, above Harptree, a carboniferous limestone basin is filled with a siliceous liassic deposit, in which are an abundance of *Lima gigantea* and *Pecten Pollux*, whilst to the south-west this formation is six miles removed. In examining some blocks of conglomerate brought out of the above workings, I detected part of a *Cidaris Edwardsii*, and was thus induced to give a closer attention to it than I otherwise intended. The shaft was then covered up, but near it was a small heap of blue clay in which I found *Rhynchonella variabilis*, and fragments of other shells, evidently of liassic age. I was informed by one of the miners that this clay had been brought from the lowest part of the mine, before it had ceased working. To prove the correctness of this statement, and learning that the ladders had been left in, I induced the manager of the adjoining works to uncover the shaft that I might go down for its examination—a work, from the state of the shaft, not unattended with some danger. On descending I examined several of the upper galleries, and found the materials therein chiefly composed of crystalline carbonate of lime, giving place occasionally to sulphate of barytes, conglomerate, and thin bands of vertical limestone, with all the ordinary features of a mineral vein. From the end of one of the galleries, at a depth of 90 feet I secured some samples of what appeared to be a sandy deposit, but which, when washed, was found to be almost entirely composed of the dismembered joints of *Encrinites*, chiefly (if not wholly) of the carboniferous limestone age, and with occasional small pebbles of hæmatite iron ore. Proceeding to the bottom of the shaft, at a depth of 270 feet, I had the pleasure of reaching the object of my search, and there found a deposit of deep blue or greenish clay, 12 feet thick, giving the appearance of having in places been deposited in thin horizontal layers, and therefore slowly, while at other spots it presented a more conglomeratic character, and contained driftwood, pebbles, &c. Owing to the difficulties attending the undertaking, and its satisfactory issue, I never returned to daylight with greater satisfaction than on this occasion. Having arranged for the removal of a quantity of the clay to Bath, it was there subjected to a long examination, and resulted in my finding a fauna in great part new to this country. Although certain that the deposit belonged to the lower lias, I was then unable to determine with any precision the exact horizon it would occupy when compared with any of the known stratified beds. There can be little doubt that the liassic seas at this period occupied the profound depths of the carboniferous limestone fissures, within which the organic remains were probably living contemporaneously with the deposition of liassic beds at other points. The delicacy and perfect condition of the fossils show that their presence is not due to the denudation and the redisposition of previously existing beds within the fissures. We may deem it a most interesting fact and one most difficult to account for by those who still advocate the plutonic origin of mineral veins, that from this one locality there have been obtained at least 115 species of fossils below the Mendip horizon for workable minerals. A few of these in the vein above, and also in the clay at the base, are, as might be expected, derived from the carboniferous limestone; but these specimens are readily distinguished from those of liassic age, and are not more than twenty in number; they consist chiefly of different species of bryozoa and corals, with three species of brachiopoda, viz., *Terebratula hastata*, *Orthis Michelini*, and *Atrypa*. I found, therefore, under these peculiar circumstances, about ninety-five species of lower liassic organisms,—a larger fauna than had up to this time been obtained from any stratified bed of that age, or, I might almost say, from the whole liassic formation in this country. Although the veins are chiefly productive in their upper portions, the blue clay in which these remains are found is mineralized, and contains almost seven per cent. of galena. The wood in it is converted into jet, and its cells filled occasionally with that mineral. On perusing the following list, and comparing its general fauna, it will be seen that many of the species are identical with those from Brocastle in South Wales; and these again with others from the Sutton stone, to be hereafter noticed; whilst both those localities will be found to have species in common to the so-called Infra-lias of the Côte d'Or, Valogne, Luxembourg, and Hettange. By an accident, several species of *Foraminifera*, in addition to the twelve given in the list, were lost. These are intimately connected with those from the *Foraminifera* zone at the top of the lower lias at Camerton. Eleven species of *Entomostraca* are included in the list, and for their examination I am indebted to my friend, Professor Jones, F.G.S., who, however, assures me that the known forms belong to species occurring in the carboniferous rocks, some having been found also in the Permian; and that the new species have their allies in the same deposits. The *Brachiopoda* are of nine genera, several of them being specifically identical with forms from the upper lias and inferior oolite. Leaving out the minute *Gasteropoda* which appear to unite this deposit with the continental beds, the general facies of the former would connect it with the upper portion of the lower lias; and the presence of *Belemnites acutus*, which hitherto has not been found lower than the upper of the *Ammonites Bucklandi* beds, would strengthen this conclusion. Several small casts of *Ammonites* were found with them, but cannot be recognized specifically. Both palæontologically and as bearing upon my view of the former physical condition of the Mendip Hills, the recognition for the first time of a terrestrial fauna will be considered of some interest. From the tertiary downwards, until the discovery by Dr. Dawson of a species of *Pupa* in the coal beds of Nova Scotia, no evidence had been obtained of any terrestrial mollusca, and there still remains the wide interval to be filled up. In this I have much pleasure in assisting, by recording the presence of three genera of land shells at the bottom of the Mendip mine, in the deposit above noticed. These are *Vertigo*, *Proserpina*, and *Helix*. I have the honour to propose for them the specific names *Vertigo Murchisoni*, *Proserpina Lyelli*, and *Helix Dawsoni*. A single seed-vessel of *Chara*, which unfortunately is not in good condition, indicates the presence of aquatic plants, and the occurrence of the genera *Valvata* and *Planorbis* establish the presence of terrestrial streams, and their communication with the Mendip fissures" (Moore). The remarkably high degree of preservation of some of these remains can scarcely be more strikingly displayed than by some of the gasteropods retaining in part their ornamentation, and occupying, to all appearance, the kind of habitat which we might expect they would frequent during life. Thus Moore, referring to the gasteropods of Brocastle, states "it is rarely that they can be recognized in the matrix of the stone itself in this section; they are, rather, usually attached to its outer surface or to the hollows presented by the conglomeratic character of the body." The differences in the general fauna found at the different localities is probably not entirely due to diversity of age, for, if we mistake not, some localities abound more in what were probably shore-dwellers than others, and the deposits clearly indicate that some of them were deposited close to the ocean margins, while others were being formed at the same time in deeper water. This point is, apparently, somewhat obscured in the list given by Mr. Moore, owing to no distinction being made between those forms which are confined to or prevailed in the shore beds or conglomerates and cavernous limestones, and those which are most abundant in the deeper water deposits. The following list, drawn up by Mr. Moore, comprises only a portion of those found in the lower lias of Somersetshire and Glamorganshire, and numbers no less than 429 species, while the middle and upper lias of western England have yielded about 580 species only.

	Camel.	Laleston.	Sutton Stone.	Do. Shepton.	*A. Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Plantæ.															
Chara liassica, Moore	—	—	—	—	—	—	—	—	*						
Araucarites peregrinus, Sternb.	*	—	—	—	—	—	—	—	—	—	*				
Protozoa.															
Foraminifera.															
Cristellaria costata, D'Orb.	*	—	—	—	—	—	—	—	*	*	—	—	—	*	
C. crepidula, F. & M.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
C. cultrata, Mont.	—	—	—	—	—	—	—	—	—	*	—	—	—	*	
C. lituus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
C. rotula, Lam.	—	—	—	—	—	—	—	—	*	*	—	—	—	*	*
Dentalina communis, D'Orb.	*	—	—	—	—	—	—	—	*	*	—	—	—	*	
D. interrupta, D'Orb.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
D. obliqua, Lum.	*	—	—	—	—	—	—	—	*	*	—	—	—	*	
D. ovicula, D'Orb.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
D. obliquestriata, Reuss.	—	—	—	—	—	—	—	—	*	*	—	—	—	*	
D. pauperata, D'Orb.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Frondicularia complanata, Mont	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
F. striatula, Reuss	—	—	—	—	—	—	—	—	*	*	—	—	—	*	
Involutina liassica, Jones	—	—	—	—	*	—	—	—	*	*	*	—	—	*	
I. sp.	—	—	—	—	—	—	—	—	*						
Lingulina carinata, D'Orb.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
L. tenera, Born.	*	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Marginulina lituus, D'Orb.	—	—	—	—	—	—	—	—	*	*	—	—	—	*	
M. raphanus, Linn.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Nodosaria fasciæ, Linn.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
N. paucicostata, Roem.	—	—	—	—	—	—	—	—	*	—	—	—	—	*	
N. radicula, Linn.	—	—	—	—	—	—	—	—	*	*	—	—	—	*	
N. raphanus, Linn.	—	—	—	—	—	—	—	—	—	*	—	—	—	*	
N. raphanistrum, Linn.	—	—	—	—	—	—	—	—	*	—	—	—	—	*	
N. Zippei, Rol.	*	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Planularia Bronni, Roem.	—	—	—	—	—	—	—	—	*	*	—	—	—	*	
P. cornucopiæ, n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. longa, Cornuel	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
P. sp.	—	—	—	—	—	—	—	*							
Trochammina incerta, P. & J.	*	—	—	—	—	*	—	—	—	*	*	—	—	*	
Vaginulina legumen, Linn.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. lævigata, Roem.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
V. striata, D'Orb.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	
Spongida.															
Grantia antiqua, Moore	—	—	—	—	—	—	—	*							
Spongia, sp.	—	—	—	*	—	—	—	*							
Cœlenterata.															
Actinozoa.															
Astrocœnia costata, Duncan	—	—	—	—	—	—	—	*							
A. dendroidea, Dun.	—	—	—	—	—	—	—	*							
A. favoidea, Dun.	—	—	—	—	—	—	—	*							
A. gibbosa, Dun.	—	—	*	—	—	—	—	*							
A. minuta, Dun.	—	—	—	—	—	—	—	*							
A. plana, Dun.	—	—	*	—	—	—	—	*							
A. pedunculata, Dun.	—	—	—	—	—	—	—	*							
A. spinigera, Dun.	—	—	—	—	—	—	—	*							
A. reptans, Dun.	—	—	*	—	—	—	—	*							
A. parasitica, Dun.	—	—	*												
Cyathocœnia dendroidea, Dun.	—	—	—	—	—	—	—	*							
C. costata, Dun.	—	—	—	—	—	—	—	*							
C. incrustans, Dun.	—	—	*												
Elysastræa Moorei, Dun.	—	—	*	—	—	*									
E. Fisheri, Laube.	—	—	*												
Isastræa globosa, Dun.	—	—	—	—	—	—	—	*							
I. sinemuriensis, De From.	—	—	—	—	—	—	—	*							
Latimæandra denticulata, Dun.	—	—	—	—	—	—	—	*							
Montlivaltia brevis, Dun.	—	—	—	—	—	—	—	*							
M. Brodiei, Dun.	—	—	—	—	—	—	—	*							
M. Murchisoniæ, Dun.	—	—	—	—	—	—	—	*							
M. polymorpha, Terq. & Piette	—	—	*	—	—	—	—	*							
M. pedunculata, Dun.	—	—	*	—	—	—	—	*							
M. parasitica, Dun.	—	—	*												
M. simplex, Dun.	—	—	—	—	—	—	—	*							
M. Walliæ, Dun.	—	—	—	—	—	—	—	*							
M. sinemuriensis, D'Orb.	—	—	*	—	—	—	—	—	—	—	*				
M. sp.	—	*	*	*	*	—	*								
Rhabdophyllia recondita, Laube.	—	—	*												
Septastræa excavata, De From.	—	—	—	—	—	—	—	*							
Thecosmilia affinis, Dun.	—	—	—	—	—	—	—	*							
T. dentata, Dun.	—	—	—	—	—	—	—	*							
T. irregularis, Dun.	—	—	—	—	—	—	—	*							
T. Michelini, Terq. & Piette	—	—	—	—	—	*	*	*	*						
T. Martini, De From.	—	—	—	—	—	—	—	*							
T. plana, Dun.	—	—	—	—	—	—	—	*							
T. mirabilis, Dun.	—	—	*												
T. serialis, Dun.	—	—	*												
T. Walliæ, Dun.	—	—	—	—	—	—	—	*							
T. Terquemi, Dun.	—	—	—	—	—	—	—	*							
T. rugosa, Laube.	—	—	*												
T. Suttonensis, Dun.	—	—	*												
Annulosa.															
Echinodermata.															
Apiocrinus Amalthei, Quenst.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cidaris Edwardsii	—	—	—	—	—	*	—	*	*	*	*	*	*	*	
Cotylederma fistulosa	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. vasculum	—	—	—	—	—	—	—	—	—	—	—	—	*		
Cidaris sp.	*	*	—	*	*	*	*	*	*	*	*	*	*	*	*
Hemipedina Bowerbankii, Wright	*	*	—	—	—	—	—	—	*						
Ophioderma sp.	*	*	—	—	*	*	*	*	*	*	*	*	*	*	*
Pentacrinus tuberculatus, Müll.	*	—	—	—	*	*	*	*	*	*	*	*	*	*	*
P. robustus, Wright	—	—	—	—	—	—	—	—	—	—	—	—	*		
Plicatocrinus Mayalis, Desh.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Tropidaster pectinatus, Forbes.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Annelida.															
Serpula strangulata, Terq.	—	—	—	—	—	*	—	—	—	*	—	—	—	*	*
S. socialis	—	—	—	—	*	*	*	*	—	*	*				

	Camel.	Laleston.	Sutton Stone.	Do. Shepton.	*A. Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munyer.
Annelida.															
Serpula sp.	—	—	—	—	*	*	—	*	—	—	—	—	*	*	
Crustacea.															
Pollicipes rhomboidalis, Moore	—	—	—	*	—	—	—	—	*						
Bairdia plebeia, Jones	—	—	—	—	—	—	—	*	*						
B. brevis, Jones & Kirkby	—	—	—	—	—	—	—	—	*						
Cythere bilobata, Münst.	—	—	—	—	—	—	—	—	*						
C. æqualis, Jones, MS.	—	—	—	—	—	—	—	—	*						
C. spinifera, Jones, MS.	—	—	—	—	—	—	—	—	*						
C. fabulina? Jones & Kirkby	—	—	—	—	—	—	—	*	*						
C. Kutorgiana, Jones, MS.	—	—	—	—	—	—	—	*							
C. curva, Jones, MS.	—	—	—	—	—	—	—	*							
C. intermedia, Münst.	—	—	—	—	—	—	—	—	*						
C. ambigua, Jones, MS.	—	—	—	—	—	—	—	—	*						
C. Thraso, Jones	—	—	—	—	—	—	—	—	*						
Cytherella aspera, Jones	*	—	—	—	*	—	—	—	—	*	*				
Kirkbya plicata, Jones	—	—	—	—	—	—	—	—	*						
Moorea tenuis, Jones	—	—	—	—	—	—	—	—	*						
M. obesa, Jones, MS.	—	—	—	—	—	—	—	*							
Normania mundula, Jones	*	—	—	—	*	—	—	—	—	*	*				
Eryon wilmcotensis, Woodw.	*														
Scapheus, sp. nov.	—	—	—	—	—	—	—	—	—	—	*				
Insecta.															
Coleoptera, sp.	*														
Orthoptera, sp.	*														
Mollusca.															
Polyzoa.															
Berenicea Archiaci, Haime	—	—	—	—	—	—	—	—	—	—	—	—	*		
Neuropora Haimii, Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
N. sp.	—	—	—	—	—	—	—	—	—	—	—	—	*		
N. mammillata	—	—	—	—	—	—	—	*							
N. sp.	—	—	—	—	—	—	—	—	*						
Stomatopora, sp.	—	—	—	—	—	—	—	—	—	*					
Brachiopoda.															
Argiope liassina, E. Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
A. Perieri, E. Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
A. Suessei, E. Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Crania Gumberti, E. Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. liassica	—	—	—	—	—	—	—	*	*	*					
Discina Davidsonii, Moore	—	—	—	*	*	*	—	—	—	—	*				
Leptæna rostrata, E. Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*	—	*
L. Bouchardii, Dav.	—	—	—	—	—	—	—	—	—	—	—	—	*	—	*
L. Davidsonii, Bouch.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Lingula, sp.	—	—	—	—	—	—	—	*	*	*	*				
Rhynchonella concinna, Sow.	—	—	—	—	—	—	—	—	—	—	—	*			
R. egretta, Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. fallax, Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
R. furcillata, Theod.	—	—	—	—	—	—	—	—	—	—	—	*	*		
R. rimosa, Ziet.	—	—	—	—	—	—	—	—	—	—	—	*	—	*	*
R. variabilis, Schloth.	*	—	—	—	*	*	*	*	*	*	*	*	—	*	*
R. subvariabilis, Dav.	—	—	—	—	—	—	—	—	—	—	—	*			
Spirifera Walcottii, Sow.	—	—	—	—	*	—	—	—	*	*	*	*	*	*	
S. oxygona, Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. Münsterii	—	—	—	—	—	—	—	—	—	—	—	*			
S. Deslongchampsii, Dav.	—	—	—	—	—	—	—	—	—	—	—	—	*		
S. verrucosa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
Suessia, sp.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Terebratula punctata, Sow.	—	—	—	—	*	—	—	*	*	*	*	*	*	*	*
T. Waterhousei, Dav.	—	—	—	—	—	—	—	—	—	—	—	*			
Terebratulina Deslongchampsii, Dav.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Thecidium Bouchardii, Dav.	—	—	—	—	—	—	—	—	—	—	—	—	*	—	*
T. granulosum, Moore	—	—	—	—	—	—	—	—	—	—	—	—	*		
T. Moorei, Dav.	—	—	—	—	—	—	—	*	*						
T. rusticum, Moore	—	—	—	—	—	—	—	*	—	—	—	—	*		
T. triangularis, D'Orb.	—	—	—	—	—	—	—	*	*	*	*				
Zellania Davidsonii, Moore	—	—	—	—	—	—	—	*	*						
Z. Laboucherei, Moore	—	—	—	—	—	—	—	—	*						
Z. obesa	—	—	—	—	—	—	—	—	—	*					
Lamellibranchiata.															
Anomia irregularis, Terq.	—	—	—	—	—	—	—	*	—	*	*				
A. pellucida, Terq.	—	—	—	—	—	—	—	—	—	*	*				
Avicula Alfredi, Terq.	—	—	—	—	—	—	—	*	—	*					
A. Buvignieri, Terq.	—	—	—	—	—	*	—	*							
A. Dunkeri, Terq.	—	—	—	—	—	—	—	*	—	*					
A. Deshayesii	—	—	—	—	—	—	—	*							
A. decussata, Goldf.	*	—	—	*	*										
A. inequivalvis, Sow.	—	—	—	—	*	—	—	—	—	*	*	*	*	*	*
A. infraliassina, Martin	—	—	—	—	—	—	—	*	—	—	*	*			
A. nuda, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
A. sp.	—	—	—	—	—	—	—	—	—	—	—	—	*	—	*
Gervillia acuminata, Terq.	—	—	—	—	—	*	—	*							
Gryphæa incurva, Sow.	*	—	—	*	*	*	*	*	—	*	*	*	*	*	*
G. depressa, Phillips	—	—	—	—	—	—	—	—	—	—	—	*			
Hinnites, sp.	—	*	*	*	*	—	—	—	—	—	*				
H. liassicus, Terq.	—	—	—	—	—	—	—	*							
Inoceramus, sp.	—	—	—	—	—	—	—	—	—	*	*				
Isodonta Engelhardti, Terq.	—	—	—	—	—	—	—	*							
Lima gigantea, Sow.	*	*	*	*	*	*	*	*	—	*	*	—	—	*	
L. amœna, Terq.	—	—	—	—	—	—	—	*							
L. dentata	—	—	—	—	—	—	—	*	—	*					
L. Deslongchampsii, Stol.	—	—	—	—	—	—	—	—	—	—	—	*	*		
L. densicosta, Quenst.	—	—	—	—	—	—	—	—	—	—	—	*			
L. duplicata	*	—	*	*	*	*	*	—	—	*	*	—	—	*	
L. Haueri, Stol.	—	—	—	—	—	—	—	—	—	—	—	—	*		
L. Hermanni, Voltz.	*	—	—	*	*	*	*	—	—	*	*	—	—	*	
L. Hettangiensis, Terq.	—	—	—	—	—	—	—	—	—	*					
L. scrobiculata, Quenst.	—	—	—	—	—	—	—	—	—	—	—	*			
L. tuberculata, Terq.	*	*	*	*	*	—	—	*	—	*	*				
L. punctata, Sow.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Ostrea arietis, Quenst.	*	*	*	*	*	—	—	*	—	*	*				
O. intusstriata, Em.	*	*	*	*	*	—	—	*	—	*	*				
O. irregularis	*	—	*	*	*	*	*	*	—	*	*				

	Camel.	Laleston.	Sutton Stone.	Do. Shepton.	*A. Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter House.	Stout's Hill.	Weston Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Ostrea liassica	*	*	*	*	*	*	*	*	—	*	*	—	—	*	
O. monoptera, Desl.	—	—	—	—	—	—	—	—	—	—	*	—	*		
O. ocreata, Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
Pecten aequiplicatus, Terq.	—	—	—	—	—	—	—	—	—	*					
P. palosus, Stol.	—	—	—	—	—	—	—	—	—	—	—	*			
P. Pollux, D'Orb.	*	—	*	*	*	—	—	*	—	*	*				
P. sublævis, Phil.	*	*	—	*	*	*	*	*	—	*	*	*	—	*	
P. verticillus, Stol.	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. Etheridgei, Taw.	—	—	*	*											
P. textorius, Schloth.	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. Thiollieri, Martin	—	—	—	—	—	*									
P. Whatleyensis, Moore	—	—	—	—	—	—	—	—	—	—	—	—	*		
P. sp.	—	—	—	—	—	—	—	*	—	—	—	—	*		
P. dispar?	—	—	—	—	—	*									
P. Rollei, Stol.	—	—	—	—	—	—	—	—	—	—	—	*			
Pinna folium, Phil.	—	—	—	—	—	—	*	—	—	—	*				
P. semistriata, Terq.	—	*	*	*	*	*	*	—	—	*	*				
Placunopsis	—	—	—	—	—	—	—	*	—	—	—	*			
Plicatula hettangiensis, Terq.	*	—	—	—	*	*	—	*	—	—	*				
P. acuminata	—	*	*	*											
P. pellucida, Terq.	—	—	—	—	—	—	—	—	—	*					
P. spinosa, Sow.	—	—	—	—	—	—	—	—	*	—	—	—	*	—	*
P. sarcinula, Goldf.	—	—	—	—	—	—	—	*	—	—	—	*	—	*	*
P. Baylii, Terq.	—	—	—	—	—	—	—	*							
Spondylus liassicus, Terq.	—	—	—	—	*										
Arca Collenoti, Martin.	—	—	—	—	—	—	—	—	—	*					
A. pulla, Terq.	—	*	—	—	—	*	*	*	—	—	*				
A. sinemuriensis, Martin	—	—	—	—	—	—	—	*							
Astarte cingulata, Terq.	—	*	*	—	—	*	—	*							
A. exigua, Terq.	—	—	—	—	—	—	—	*							
A. acuti, Moore	—	—	—	—	—	—	—	—	—	—	—	—	*		
A. psilonoti, Quenst.	—	—	—	—	—	—	—	—	—	*					
A. irregularis, Terq.	—	—	—	—	—	—	—	—	—	*					
Cardinia elongata, Stutch.	—	—	—	—	*	*	—	*							
C. exigua, Terq.	—	—	—	—	—	—	—	—	—	*					
C. Listeri, Sow.	—	*	—	—	*	—	—	*	—	—	*				
C. Morisi, Terq.	—	—	—	—	—	—	—	*							
C. Moreana, Martin	—	—	*												
C. sublamellosus, Martin.	—	—	—	—	—	—	*								
Cardita tetragona, Terq.	—	—	*	—	—	—	*	*							
C. Heberti, Terq.	—	*	—	—	*	—	*	*	—	*					
Cardium Heberti, Terq.	—	—	—	—	—	—	—	—	—	*					
C. Phillipianum, Terq.	—	—	—	—	—	—	—	—	—	*					
C. Terquemi, Martin	—	—	—	—	—	—	—	*	—	*					
Cucullæa hettangiensis, Terq.	—	*	—	—	—	—	*	*	—	*					
C. similis, Terq.	—	*	—	—	—	*	—	*	—	—	*				
Cypricardia Bronni, Martin	—	—	—	—	—	—	—	—	—	*					
C. compressa, Terq.	—	—	*	—	—	*									
C. sp.	—	—	—	—	—	—	—	*							
C. inclusa	—	—	—	—	—	—	—	*							
C. Winwoodii, Moore	—	—	*												
Gastrochæna liassina, Terq.	—	—	—	—	—	—	—	*							
Leda Heberti, Martin	—	—	—	—	—	—	*	—	*	*					
Lithodomus arenicola? Terq.	—	—	*	—	—	—	*	*	*	*	*	*	*		
Lucina arenicola, Terq.	—	—	—	—	—	—	*								
Modiola producta, Terq.	—	*	—	*	*	*	—	—	—	—	*				
M. minima, Sow.	*	*	—	—	—	*	—	—	—	*					
M. Hillana, Sow.	—	—	—	*	*										
Mytilus arenicola, Terq.	—	—	—	—	—	—	—	*							
M. lamellosus, Terq.	—	—	—	—	—	—	—	*							
M. liassicus, Terq.	—	—	—	—	—	—	—	*							
M. Simoni, Terq.	—	—	—	—	—	—	—	*							
M. sinemuriensis, Martin	—	—	—	—	—	—	—	*							
Myacites, sp.	—	—	—	—	*	—	—	—	—	*	*				
Nucula, sp.	—	—	—	—	—	*	*	—	*	*	*				
Mya, sp.	*	—	—	—	—	—	—	—	—	*					
M. sp.	*	—	—	—	—	—	—	—	—	*					
Opis triangularis, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
O. sp.	—	—	—	—	—	—	—	—	*						
Pholadomya ambigua, Sow.	—	—	—	—	*	—	*	—	—	*	*	—	—	*	
P. arenacea, Terq.	—	—	—	—	—	—	—	*							
Saxicava sinemuriensis, Martin	—	—	—	—	—	—	—	—	—	*					
S. arenicola, Terq.	—	—	—	—	—	—	—	—	—	*					
S. Bronni, Martin.	—	—	—	—	—	—	—	*							
Tancredia securiformis, Terq.	—	—	—	—	—	—	—	*	—	*					
T. tenera, Terq.	—	—	—	—	—	*									
Unicardium cardioides	*	—	—	—	*	—	—	—	—	*	*				
Gasteropoda.															
Actæon angulifer, Martin	—	—	—	—	—	—	*								
A. sinemuriensis, Martin.	—	—	—	—	—	—	—	—	—	*					
Alaria rudis, Moore	—	—	—	—	—	—	—	*							
A. fusiformis, Moore	—	—	—	—	—	—	—	*							
Amberleya alpinus, Stol.	—	—	—	—	—	—	—	—	—	—	*				
A. apicalis, Moore	—	—	—	—	—	—	—	*							
A. grandis, Moore	—	—	—	—	—	—	—	*							
A. turrita, Moore	—	—	—	—	—	—	—	*							
Ampullaria carinata, Terq.	—	*													
A. planulata, Terq.	—	*	—	—	—	—	—	*							
A. angulata, Desl.	—	—	—	—	—	—	*								
Cerithium acuticostum, Terq.	—	—	—	—	—	—	*	*	—	*					
C. Collenoti, Martin.	—	—	—	—	—	—	—	—	—	*	*				
C. Dumortieri, Martin	—	—	—	—	—	—	*								
C. Henrici, Terq.	—	—	—	—	—	—	*	—	—	*					
C. gratum, Terq.	—	—	—	—	—	—	*	*	*	*	*				
C. Jobæ, Terq.	—	—	—	—	—	—	—	*							
C. nodulosum, Moore	—	—	—	—	*	*									
C. pellucidum, Moore	—	—	—	—	—	—	—	*							
C. pentacostæ, Moore	—	—	—	—	—	—	—	*							
C. planicostatum, Moore	—	—	—	—	—	—	—	*							
C. paludinare, Terq.	—	—	—	—	*	—	*	*	*	*					

	Camel.	Laleston.	Sutton Stone.	Do. Shepton.	*A. Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Cerithium porulosum, Terq.	—	—	—	—	—	—	*								
C. pupa, Martin	—	—	—	—	—	—	—	*							
C. rotundatum	—	—	—	—	*	—	—	—	*						
C. Semele, D'Orb.	—	—	—	—	—	*	*	*	*	*	*				
C. spiratum, Moore	—	—	—	—	—	—	—	*							
C. sinemuriensis, Martin.	—	—	—	—	—	—	—	*	—	*					
C. trinodulosum, Martin	—	—	—	—	—	—	—	—	—	*	*				
C. verrucosum	—	—	—	—	—	*									
Chemnitzia Oppeli, Martin.	—	—	—	—	—	—	—	*							
C. polita, Martin	—	—	—	—	—	—	—	*	—	*	*				
Chiton bilobatum, Desl.	—	—	—	—	—	—	—	—	—	—	—	—	*		
C. radiatum, Moore	—	—	—	—	—	—	—	*	*						
Delphinula nuda, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
D. reflexilabrum, Horne	—	—	—	—	—	—	—	—	—	—	—	*			
Dentalium, sp.	—	—	—	—	*	*	*	*	—	*					
Discohelix cornucopiæ, Moore	—	—	—	—	—	—	—	*							
D. fimbriatus, Moore	—	—	—	—	—	—	—	*							
Fusus Jenynsii, Moore	—	—	—	—	—	—	—	*							
F. Terquemi, Moore	—	—	—	—	—	—	—	*							
Helix Dawsoni, Moore	—	—	—	—	—	—	—	—	*						
Hydrobia, sp.	—	—	—	—	—	—	—	—	*						
Littorina circularis, Moore	—	—	—	—	—	—	—	*							
L. ovalis, Moore	—	—	—	—	—	—	—	*							
L. clathrata	—	—	—	—	*	*	—	—	—	—	*				
Melania acuta, Moore	—	—	—	—	—	—	—	*							
M. abbreviata, Terq.	—	*	*	*	—	—	—	*	*	*	*				
M. crassilabrata, Terq.	—	—	—	—	—	*									
M. dubia, Terq.	—	*	—	*	—	—	—	*							
M. nodulo-carinata, Moore	—	—	—	—	—	*									
M. dunravenensis, Moore.	—	—	—	—	*	*	*	—	—	—	*				
M. Theodori, Martin	—	—	—	—	—	*									
M. usta, Terq.	—	—	—	—	—	—	—	*							
Nerinæa acuminata, Moore	—	—	—	—	—	—	—	*							
N. Horneri, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
N. mendipensis, Moore	—	—	—	—	—	—	—	—	*						
N. rudis, Moore.	—	—	—	—	—	—	—	*							
Neritina arenacea, Terq.	—	—	—	—	—	—	—	*							
N. canalis, Terq.	—	—	—	—	—	—	—	*							
N. hettangiensis, Terq.	—	—	—	—	—	*									
Neritopsis exigua, Terq.	—	*	*	—	—	—	—	*							
N. cancellatus, Terq.	—	—	—	—	—	—	—	*							
N. lævis, Stol.	—	—	—	—	—	—	—	—	—	—	—	*			
Orthotoma avena, Terq.	—	—	—	—	—	—	*	*							
O. frumentum, Terq.	—	—	—	—	—	—	—	*	*						
O. oryza, Terq.	—	—	—	—	—	—	—	*	—	*					
O. triticum, Terq.	—	—	—	—	—	—	—	—	*	*					
O. sp.	—	—	—	—	—	—	—	—	—	*					
Patella ornata, Moore	—	—	*	—	—	—	—	*							
P. Dunkeri, Terq.	—	—	*	—	—	—	—	*							
P. Schmidti, Terq.	—	—	—	—	—	—	—	*							
Phasianella liasina, Terq.	—	—	—	—	—	—	—	*	—	*					
P. turbinata, Stol.	—	—	—	—	—	—	—	—	—	—	*				
P. nana, Terq.	—	—	—	—	—	—	—	*							
Planorbis mendipensis, Moore	—	—	—	—	—	—	—	—	*						
Proserpina Lyelli, Moore	—	—	—	—	—	—	—	—	*						
Pterocheilos primus, Moore	—	—	—	—	—	—	—	*							
Pleuratella primus, Moore	—	—	—	—	—	—	—	*							
Pleurotomaria concava, Martin	—	—	—	—	—	—	*								
P. anglica, Sow.	—	—	—	—	—	—	—	—	—	—	*	—	—	*	
P. expansa, Sow.	—	—	—	—	*	—	—	—	*	*	*	—	—	*	
P. mendipensis, Moore.	—	—	—	—	—	—	*								
P. densa, Terq.	—	—	—	—	*										
P. hettangiensis, Terq.	—	—	—	*											
P. Buchi, Desl.	—	—	—	—	—	—	—	—	—	—	—	*			
P. Mozellanus, Terq.	—	—	—	—	—	*									
P. nucleus, Terq.	—	—	—	—	—	—	—	—	—	*					
P. Hennocquii, Terq.	—	—	—	—	—	—	—	—	—	*					
P. Henrici, Martin	—	—	—	—	—	—	—	*							
P. lens, Terq.	—	—	—	—	—	—	—	*							
P. rotelliformis, Dunk.	—	—	—	—	—	—	—	*							
P. trocheata, Terq.	—	—	—	—	—	—	—	—	—	—	*				
Purpurina tricarinata, Martin	—	—	—	—	—	—	—	—	—	*					
Pyrula liassica, Moore	—	—	—	—	—	—	—	*							
Rimula elegans, Moore	—	—	—	—	—	—	—	*							
R. liassina, Terq.	—	—	—	—	—	—	—	*							
R. sp.	—	—	—	—	—	—	—	—	*						
Solarium lunatum, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
S. lenticulare, Terq.	—	—	—	—	*	—	—	*	*						
Straparollus Oppeli, Martin	—	—	—	—	—	—	—	*	*						
S. tricarinatus, Terq.	—	—	—	—	—	—	—	—	*	*					
Trochotoma brocastellensis, Moore.	—	—	—	—	—	—	—	—	*						
T. Lycettii, Moore	—	—	—	—	—	—	—	—	*						
Trochus apicalis, Moore	—	—	—	—	—	—	—	—	*						
T. Deslongchampsii, Moore	—	—	—	—	—	—	—	—	*						
T. epulus, Stol.	—	—	—	—	—	—	—	—	—	—	—	—	—	*	*
T. gradatus, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
T. Juliani, Terq.	—	—	—	—	—	*									
T. Langanensis, Moore	—	—	—	—	—	*									
T. nitidus, Terq.	—	—	—	—	—	—	—	*							
T. latilabrus, Stol.	—	—	—	—	—	—	—	—	—	—	—	*			
T. Elizæ, Moore	—	—	—	—	—	—	—	*							
T. holwellensis, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
T. tubicola, Terq.	—	—	—	—	—	—	—	—	—	*					
T. Piettei, Martin	—	—	—	—	—	—	—	—	—	—	*				
T. sinistrorsus	—	—	*												
Turbo solidus, Moore	—	—	—	—	—	—	—	—	—	—	—	*			
T. apicalis, Moore.	—	—	—	—	—	—	—	*							
T. brocastellensis, Moore.	—	—	—	—	—	—	—	*							
T. costellatus, Terq.	—	—	—	—	—	—	—	*	—	*					
T. gemmatus, Terq.	—	—	—	—	—	—	—	*	—	*					
T. liassicus, Martin	—	—	—	—	*	—	—	—		*	*				
T. nodulo-carinatus, Moore	—	—	—	—	—	—	—	—	—	—	—	*			

	Camel.	Laleston.	Sutton Stone.	Do. Shepton.	*A. Bucklandi.*	Southerndown, do.	Bridgend.	Brocastle.	Charter House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Turbo manus, Martin.									*	*					
T. Orion, D'Orb.												*			
T. striatus								*							
T. reticulatus, Moore								*							
T. tumidus, Moore								*							
T. triplicatus, Martin							*								
T. Pietii, Martin								*	*	*					
T. Martini, Terq.									*						
Tornatella Buvignieri, Terq.							*	*							
T. secale								*							
Turritella Dunkeri						*									
T. Deshayesii, Terq.					*	*	*								
T. Howsei, Moore								*	*						
T. Humberti, Martin						*	*		*	*	*				
T. Jenkeni, Terq.				*		*	*			*					
Valvata anomala, Moore									*						
V. pygmæa, Moore									*						
Vertigo Murchisonæ, Moore									*						
Cephalopoda.															
Ammonites planorbis, Sow.	*	*								*					
A. Johnstoni	*		*		*	*									
A. angulatus	*		*		*	*	*			*	*			*	
A. Bucklandi, Sow.				*	*	*	*			*	*			*	
A. Conybeari, Sow.				*	*					*	*			*	
A. Sauzianus, D'Orb.						*	*								
A. semicostatus						*	*							*	
A. Turneri, Sow.											*			*	
A. obtusus				*	*										
A. young form						*	*	*	*	*	*				
Belemnitis acutus, Mill						*	*		*	*	*		*	*	*
B. clavatus													*	*	*
B. elongatus? Mill						*									
Nautilus striatus, Sow.	*				*						*				
N. intermedius, Sow.	*				*					*	*			*	
N. young sp.								*							
Geoteuthis											*				
Fish remains															
Ichthyosaurus platyodon															
Plesiosaurus rugosus															

This list presents several interesting features, some of which have been pointed out by Mr. Moore himself. It indicates that the general poverty of the lias in corals is due, not to the circumstance that those beings were actually rare in liassic times, but because we have seldom chanced to hit upon those localities and strata in which they prevail. The general fauna has in many respects the apparent facies of one that might be expected to frequent rocky shores and shallow seas, as is witnessed by the species of *Fusus*, *Patella*, *Littorina*, *Trochus*, *Gastrochæna*, &c.,—genera which especially frequent such habitats on our coasts at the present time. The corals are unknown on our coasts now in such variety and profusion; but call to mind the coral-clad shores of warmer climes.

The middle and upper lias are well represented in Dorsetshire, where, however, the upper surfaces of the beds appear to have undergone considerable denudation. The middle lias embraces upwards of 500 feet of strata. The marls of the lower lias pass up into the limestones and marls of the middle lias, the limit being marked by some bands of limestones in which *Ammonites raricostatus* is somewhat abundant, although it is not known to ascend higher. *Belemnites* are remarkably abundant, the prevalent forms being *B. elongatus* and *B. longissimus*. These beds also yield the remarkable cephalopod *Xiphoteuthis Bechei*. The part of the series marked by these *Belemnite* beds comprises about 80 feet of blue and grey non-micaceous marls, in which the limestones form subordinate bands. At about this level there are several veins of nodules containing *Ammonites*, whose chambers are partially filled with a greenish calc spar, whence they are termed the 'green *Ammonites* beds.' Grey marls to the extent of seventy feet or more overlie these, and then occur the 'three tiers,' or three layers of a fine-grained micaceous calcareous sandstone. This is said to be the lowest horizon in the Dorsetshire middle lias at which mica makes its appearance, a mineral which is usually present in the marls above this point. The grey micaceous marls, with a few intercalated sandstones, succeed for about 150 feet, at the highest part of which are two thin highly fossiliferous bands, of which the lower is called 'the shell bed,' from the great abundance of molluscan remains yielded by it; and the other is the 'star-fish bed,' so called on account of the fine specimens of *Ophioderma Egertoni* and *O. tenuibranchiata* which it has afforded. After this a marked change sets in, for sands more or less marly, and with nodules of indurated sand, prevail for the next 150 or more feet. A little above the central portion is a band of blue micaceous siliceo-calcareous stone, designated the '*Margaritatus* stone,' from its abounding in *Ammonites margaritatus*. These sands might be considered to terminate the middle lias, since the clay which overlies it is admittedly of upper liassic age, and it might be expected that the change of fauna would in the main coincide with the change of conditions. Mr. Day, however, maintains that the middle lias certainly includes the lower portion of this clay; but we will give his own statement respecting the matter. "Over these upper sands, which are frequently indurated into massive blocks of sandstone rather than into nodules, and which form the 'blue band' upwards, measuring about 70 feet in thickness, is a mass of very micaceous grey marl or clay about 18 feet in thickness. This is capped by a remarkable band of stone, the lower portion of which is in great part a conglomerate, the pebbles being imbedded in a more or less ferruginous matrix with oolitic granules. In places, however, this part of the bed assumes more the appearance of the marl-stone of other districts: it is separated from the higher portion of the stone by a seam of iron ore, seldom more than an inch in thickness, but occasionally becoming thicker, and then containing a remarkable assemblage of *Mollusca* amongst the water-worn pebbles. This '*Pleurotomaria* bed,' as I have termed it, and the underlying equivalent of the Marlstone, appear not to be persistent through the section, but the upper portion of the bed of stone can be traced throughout. This higher part is composed of thin bands of a hard, dense, almost chert-like, limestone, separated by thin laminæ of yellow ochreous clay; the whole, however, being consolidated into one block. The entire thickness of the associated marlstone and limestone (belonging to the upper lias) varies from two to three feet. This extraordinary band of stone, thus including the boundary line of two formations, is interposed between portions of the same great clay deposit, since above it there is a mass of grey micaceous marl precisely similar in character to that below. This marl is continued upwards for about 70 feet. We have already seen that blue marl, similar to that of the lower lias, is continued some 20 feet into the *Belemnite* beds of the middle division; here, on the contrary, we find the higher limit of the latter, as defined by fossils, carried upwards into a clay deposit most certainly belonging in the mass to the upper lias. We thus see that the organic and inorganic conditions characteristic of two contiguous groups do not always possess the same boundary line." This stone is more especially interesting as it closely resembles some of the South Wales lower lias beds, and appears to have been formed under somewhat similar circumstances. Mr. Day mentions the pebbles and small boulders, the perforations of *Lithodomi*, the collection of shells in the hollows of the conglomerates, the *Serpulæ* on the shells and pebbles; all which points have their parallel in the Brocastle beds.

In the north of France the liassic beds are, generally speaking, poorly developed whether as regards the variety of stages or the thickness of the deposits. In the department of Yonne, or near the centre of France, the upper, middle, and lower lias occur, the former two being of considerable thickness, while the last is thin. The range is apparently from the zone of *Ammonites Bucklandi* below to that of *Am.-communis* above. The lower lias consists of limestones having an aggregate thickness of about 16 feet. The middle lias is 180 feet thick, of which the lowermost 16 feet consists of highly argillaceous limestones, the next 155 feet of marls, abounding in septaria, but unfossiliferous, while the remainder is made up of limestones with clay partings. The upper lias is about 155 feet thick, the lower 93 feet being made up of alternations of laminated clay and argillaceous limestone, and the remaining 62 feet of alternations of marl with limestone. There is here an entire want of that arenaceous element which prevails towards the higher part of the series in Dorsetshire. Farther north-west, or in the department of Ardennes, sandy beds enter largely into the composition of the upper part of the series as in Dorsetshire.

(Moore, C., *Quar. Jour. Geol. Soc.* xxiii. p. 449—568; Tate, R., *Quar. Jour. Geol. Soc.* xx. p. 103; xxiii. p. 297—314; D'Archiac, *Histoire des Progrès de la Géologie*, tomes 6 and 7.)

LIEBERKUHNIA [FORAMINIFERA, E. C. S.].

LIGNITE [E. C. vol. iii. cols. 429—430]. This term is applied to those collections of vegetable matter, whether wood or not is immaterial, which have undergone so considerable an amount of change, both physical and chemical, that the original structure is for the most part indistinct to the unassisted eye. It merges so gradually into peat on the one hand, and into coal on the other, that no definition can be applied which will not embrace some varieties either of peat or coal. One of the best definitions is the German term "brown coal," which implies a more or less compact carboniferous substance, which makes a brown streak. Coal, on the contrary, gives a black streak. This distinction is not universal, for there are a few lignites which have a black streak. Most of the properties by which lignite differs from coal are intimately associated with this brownness. Coal is carbon combined with a very small proportion of bituminous (ulmous or humous) substances; while lignite is carbon associated with a large proportion of the same; the carbon alone is black, but when mingled with bituminous matter, it is more or less brown when reduced to powder. Lignite readily lights, but produces a dull smoky flame, and an intensely disagreeable empyreumatic odour. Coal, on the other hand, is more difficult to light, burns with a clearer flame, and yields less smoke, and comparatively little odour. As will be seen, lignite partakes of the nature of a rock, inasmuch as it is composed of mixtures of definite chemical compounds. As the proportion of the ingredients, as well as the number of them which are present, are variable, it necessarily happens that the lignite itself is variable. Indeed it is rare to find two specimens alike, either in physical or chemical points; and indeed the same bed may vary within very narrow limits. Differences not only arise from the original divergencies in the matter forming the lignite, but also from the variation in the nature and intensity of the agents to which it is subjected. There is little or no question that all lignite is of vegetable origin, although the question was keenly discussed by the physicists and chemists of last century. It is derived from plants of every description, from the lowly seaweed and tender flowering plants to the largest and hardest trees; but in nearly all cases the principal preservative agent is water. Hence lignite deposits, like bogs and peats, generally indicate where water of the period of their formation was accumulated. They indicate the sites of old estuaries, lakes, marshes, and swamps. Sometimes the material has been transported to the place where it now lies, but more frequently it is formed partially or mainly of plants which have grown and died on the spot. Hence it is that most beds of lignite rest upon a surface impermeable to water. Here we have two sets of conditions, which may greatly influence the kind and rapidity of the alterations of lignite; if it rests upon and is covered by clay, water circulates with great slowness, and the changes of state are effected but tardily; whereas if it is enveloped in sand the greater activity of circulation will promote the metamorphism of the plants and lignite. Much also may depend upon the nature of the water, for the volatile elements of the plants will be more readily carried off by some than by others. Pressure also has a great influence in inducing change. Again, differences are induced by the presence of sand, clay, &c., within the pores and interstices of the wood and vegetable matter in variable proportions; and these influence the physical properties, and the degree of susceptibility to change. So many, indeed, are the conditions to be taken account of that it is difficult to express them all; but their multiplicity, although confusing to a student, is an advantage, for they will greatly aid him who can master them. When one has succeeded in tracing what properties or intensities of property result from each set of conditions, lignite will afford a most delicate means of interpreting some of the events which have happened in distant geological ages. Lignite, however, does not occur of every geological age, although it is probable that the conditions corresponding to those favourable for its formation have prevailed during the deposition of every group of rocks. In the oldest rocks anthracite is the prevalent carbonaceous deposit; in the carboniferous series coal predominates; in the secondary, but more especially the tertiary strata, lignite is the form which the enclosed vegetable matter usually assumes; and peat is the characteristic phase of such matter in the newest strata. Although anthracite, coal, lignite, and peat may have been derived from vegetable masses, whose original composition, both physically and chemically, were variable for each kind of fuel, and perhaps in groups distinct one from the other, yet they were so far similar that they all consisted mainly of carbon, hydrogen, and oxygen. One distinctive feature occurs to us, viz., that whereas peat and coal usually contain from 1 to 2 per cent. of nitrogen, lignite rarely has so large a proportion of that element. Allowing for this, and allowing that they were not all derived from one kind of wood, or even any wood, the following table will give a general idea of the amount of alteration chemically each has undergone, which alteration is probably similar for each kind of fuel when placed under similar conditions:—

	Carbon.	Hydrogen.	Oxygen.
Wood	100·	12·18	83·07
Peat	100·	9·85	55.76
Lignite	100·	8·37	42·42
Coal	100·	5·91	18·32
Anthracite	100·	2·84	1·74

This table represents the average proportion of the three principal elements, not the analyses of these substances. The hydrogen and oxygen is diminished relatively to the carbon according to their average antiquities. The change is perhaps more strikingly shown if the carbon be contrasted with the two other elements combined, as thus:—

	Carbon.	H. & O.
Wood	100·	95·25
Peat	100·	65·61
Lignite	100·	50·79
Coal	100·	24·23
Anthracite	100·	4·58

The change does not merely consist in the decrease of the hydrogen and oxygen; a portion of the carbon is also given off, but it vanishes less rapidly than the others. Moreover, the carbon in wood is wholly combined with the other elements, whereas in lignite and coal a large proportion is isolated or withdrawn from combination; and in anthracite almost all the carbon is free. The changes are constantly going on. Gas companies endeavour to obtain the coal as fresh as possible, for they find that if it is allowed to lie exposed to the air for a few months its gas-yielding properties are seriously impaired; and lignite suffers a similar alteration when exposed. Lignite differs from coal in the large proportion of hygroscopic water it contains. Sometimes such water forms one half the weight of the lignite. The lignite of Westerwald contains 22 per cent. of water after having been dried at 212° F.; while that of Salesl in Bohemia only yields 2 per cent. Dried lignites regain the moisture from the atmosphere, but at very different rates, and the total quantity acquired is also variable. In 24 hours 6, or even 15 per cent., by weight of the lignite, of hygroscopic water may be taken up.

The lignites vary amongst themselves in an analogous way to the carbonaceous substances already mentioned. As a general rule, the eocene lignites are richer in carbon than those of miocene and pliocene times; while the latter usually contain more oxygen and hydrogen than the former. In order to exemplify this variety we select from some hundreds of analyses half-a-dozen each from the groups containing the largest, the mean, and the smallest proportions of carbon:—

Locality.	Kind of Lignite.	Sp. gr.	C.	H.	O.	S.	Ash.	Hygroscopic Water.	Analyst.
Wigan: U.S.	Earthy lignite.		80·21	6·30	8.54				Philippi.
Grünlas, Bohemia . . .	Dull "pechkohle."		78·96	7.55	13·49				
Isle of Mull	Common lignite.		76·44	6·42	17·14				
Monte Bamboli, Italy . .	"Pechkohle."	1·35	73·81	5·09	17·44		3·65		
Brennberg, Hungary . .	Laminated; dull lustre.	1·30	71·9	5·14	22·89	·7	3·4	17·8	Cassel-mann.
Westerwald			70·26	6·4	21·4		1·9	48·5	
Bensberg, Bavaria . . .	"Pechkohle."		69·50	4·63	20·47	1·6	3·8		
Bovey, Devonshire . . .	Brown lignite.	1·12	66·31	5·63	22·86	2·36	2·27	84 66	Vaux.
					n=·565				
Perleberg, Prussia . . .	Earthy lignite.		64·	5·	27·5		3·3	17·3	Heintz.
Hirschberg	Common lignite.	1·05	62·90	5·7	17·	7·8	6 6		Gräger.
Meissen, Saxony . . .	Earthy and dark.		62·18	5·47	18·05	9·3	5·0		Gräger.
Riestadt, Prussia . . .	Lignite.		61·13	5·09	31·95		1·83		Bischof.
Gouze	"Pechkohle."		47·62	5·10	33·28	3·	12·		
Sagor	Ditto.		47·40	5·58	33·02	3·	11·		
Cadibona, Italy . . .	Ditto.		46·5				6·10		
Monte Nerona	Ditto.		46·3				6·9		
Voitsberg	Lignite.		44·88	6·18	41·24	1·05	5·2		
Polnisch Neudorf . . .			34·6	3·8	19·3		28·3	14·	Heintz.

Lignite occurs under so many circumstances, in so many localities, and in so many strata, that it would be quite beyond our limits to give details; but these may be acquired by a perusal of Zincken's 'Die Physiographie der Braunkohlen,' 1867, a work which contains a summary of almost every important paper or book that has been printed respecting lignite. It has ample references to lignite deposits indicating whether they were formed in estuaries, or in lakes, or on the shores of the sea; and mentioning all in each country arranged in geographical order. The work is replete with valuable information on lignite. The following account of the varieties of this substance is condensed from it.

Common brown coal. It generally forms thick, compact masses, retaining but rarely faint traces of woody structure. The fracture is earthy, or flat, or conchoidal; the lustre is dull, or slightly glimmering; the colour varies from light to dark brown, and the streak has a greasy lustre. It occurs in beds composed of irregular lumps, which are frequently angular, or even approach the regularity of a parallelopipedon in shape. It comprises the varieties called "stick coal" (*Stück-kohle*), "gristly coal" (*Knorpel-kohle*), and "moulded coal" (*Form-kohle*).

Earthy brown coal. This is an earthy variety, the colour of which ranges from yellowish, through light and dark-brown, to brownish-red. Its fracture is dull and uneven, but when rubbed with the nail the surface takes a slight polish. It presents no signs of organic structure. Its amorphous character and susceptibility of being reduced to a powder is a consequence of its origin. When plants are long macerated in water the cells are burst, and the substance is reduced to a pulverulent condition. The vegetable matter which forms this lignite has undergone this treatment. The *Schweel-kohle*, *Schmier-kohle* (oil-coal), *Aschen-grund* (ground-ashes), *Cölnische umbra* (Cologne earth), and *Ruis-kohle* (soot-coal) of the Germans are varieties.

Lignite, in the restricted sense, is applied to the more or less fossilised masses of wood which still retain clear trace of structure. Its colour ranges from yellow to dark-brown; the specific gravity from ·5 to 1·4. Its fracture resembles that of wood, being uneven when broken across the fibre, or even splintery. Some lignites when dried acquire the peculiarities of *Pech-kohle*.

Slaty lignite is so called from its being composed of thin laminæ. Its colour is usually dark brown, the cross fracture is uneven, and dull, or occasionally lustrous.

Leaf coal or Dysodil is mainly composed of the leaves and stems of plants, and often encloses remains of numerous terrestrial organisms. Its colour varies from gray to dark brown. It is essentially a fresh-water deposit.

Rush coal consists of reedy, long-stemmed fragments, which are frequently intertwined together. The surfaces of the reeds have the colour and lustre of pitch, and the cross fracture is finely granular.

Moor-coal is a compact mass formed of minutely divided fragments of wood, stems, roots, and decomposed marsh plants. By pressure it is rendered laminar, the laminæ being in some cases thick, in others thin. The colour is dark brown, or pitch black, and the specific gravity ranges from 1·2 to 1·3.

Pitch coal is compact, breaks into fine, angular fragments, possesses a dark colour, and a slight lustre. Its streak is brown; it colours a solution of potash dark brown. It is frequently a modification of the more compact and bituminous lignites, and passes by its varieties into common brown coal on the one hand, and *Glanz-kohle* on the other. The hardness is 2·5, and the specific gravity 1·2—1·3.

Glossy coal (*Glanz-kohle*), is compact in texture, breaking with a conchoidal fracture, and presenting a lustre varying from that of grease to that of some metals. It is the densest and hardest of the lignite group, the hardness being 2·5 to 3·0, and the specific gravity 1·2—1·5. It is formed from highly bituminous plant remains, resinous wood, and is sometimes formed from the action of volcanic rocks upon some of the lighter lignites.

Jet is a very dark and compact lignite which readily takes a fine polish, and is highly charged with bituminous matters.

Stick-like lignite is applied to the kinds which readily break into prismatic splinters several inches in length.

Graphite. According to Rink there is a layer of this substance at Karsok, in North Greenland, which has originated from a lignite acted on by a dolerite.

LIMESTONE [E. C. vol. iii. cols. 440—685]. The cultivators of the botanical and zoological sciences have furnished students with a profusion of monographs; but the lithologists have produced exceedingly few. Excellent examples of this kind are afforded by the great work of Messrs. Geinitz, Fleck, and Hartig on coal, but this is restricted to Europe; and to complete the survey, one requires to study the works of Lesley, Rogers, and others, for an account of the American coals; while those of other regions are treated of in scattered publications. Again, Senft has rendered good service by his monographical account of peat and allied substances. Zincken has collected nearly all that is known about lignite. The carbonaceous group fares better than most; but limestone and calcareous rocks have never had a monograph devoted to them which would epitomise our knowledge respecting them. The subject is a rich one, the materials are abundant, and there are interesting scientific questions involved in their treatment. Limestone is amongst the most abundant, wide-spread, and ubiquitous of rocks. It differs from most others in its mode of origin, the manner in which its material is circulated, the conditions under which it is formed, and in being most intimately associated with organic life. It is believed that all the limestone in existence has at one time formed a portion of the hard parts of some organic being; and that hence its distribution is so wide. A limestone or calcareous ooze may be forming now under almost every group of conditions which permit of the accumulation of a deposit; a remark which will not apply to any but calcareous rocks. It may be produced by a spring flowing over the land, as in calcareous tufas; it may form in a river, or in a delta, or along the shore, or in deep ocean. The situation of siliceous rocks depends upon the force of the currents, and they are rarely built up far from land, since the finest argillaceous or siliceous sediment will settle where the influence of the fluviatile currents are lost. Oceanic currents carry little or no land-derived matter in suspension. An illustration of the opposite relations of limestones and detrital rocks, is given under CARBONIFEROUS SYSTEM, E. C. S. col. 201.

If it be established that all marine limestones owe their origin to the action of organic beings, it may be admitted as highly probable that limestones have always been forming over as large an area as calcareous ooze now prevails; that is, over more than half the oceanic area. It would occupy us too long to detail the facts which appear to support this conclusion. But if we accept it, and consider what the stratigraphical distribution of limestones is, we shall be impressed with the unstable nature of the earth's external surface. No locality examined has been permanently beneath a deep ocean, since nowhere do we find a limestone prevailing from the lowest to the highest strata; and wherever the geologist has been able to explore, it may be said that no place has been deep ocean throughout a whole epoch. Comparing calcareous strata with those of a detrital nature, we are at once struck with the disproportionate thicknesses of the two. It is very rare indeed for a limestone, or a succession of limestones, to exceed 1000 feet, but there are many instances where detrital strata are piled up for more than a thousand feet, and not a few where many thousand feet of mechanically formed beds are heaped together. In illustration of this and some other considerations, which we shall allude to in the sequel, we will give a rapid summary of the distribution of palæozoic limestones in time.

The Laurentian strata are developed to a thickness of upwards of 30,000 feet, and were at one time regarded as forming a portion of the great heterogeneous mass of azoic rocks. The lower Laurentian of Canada is about 18,000 feet thick, and comprises several highly crystalline bands of limestone, one of which has a length of hundreds of miles, and a thickness varying from 700 to 1500 feet. This is one of the earliest deposits of calcareous matter yet discovered, and at the same time it is one of the thickest. The Laurentian strata have not been fully investigated yet, but at present there are known to be at least three important limestone bands in the lower Laurentian series; and it is not unlikely there may be more. In the neighbourhood of the Ottawa river immense masses of orthoclase gneiss alternate with crystalline limestones. The lowermost mass, the base of which has not been detected, is an orthoclase gneiss, which is believed to be more than 5000 feet thick. Above it follows a crystalline limestone, 1500 feet thick. A second gneissic band, 4000 feet thick, intervenes between this and the second limestone band, the thickness of which is 2500 feet. It is not wholly limestone, since it comprises a few subordinate bands of hornblendic orthoclase gneiss, similar in character to the gneiss which bounds it. Orthoclase gneiss again succeeds for 3500 feet, followed by the crystalline limestone of Grenville, with an average thickness of 750 feet. Orthoclase gneiss, 1580 feet thick, overlies the Grenville limestone. Here, then, we have a total of 18,300 feet of strata, of which about 4750 feet is calcareous. Farther west in Hastings county the lower Laurentian strata are also exposed, but it would seem that they belong to a different part of the series from the beds near the Ottawa. The lowermost strata comprise 5000 feet of hornblendic orthoclase gneiss; above this is a zone of 200 feet of green chloritic slates, next follow 2200 feet, of which the greater proportion consists of highly crystalline white limestone, associated with subordinate layers of dolomite, quartz, and micaceous slates. Above this the micaceous slates prevail for 900 feet, but contain one band of dolomite, 60 feet thick; while another band of dolomite, 100 feet thick, caps it. To this succeed 2000 feet of calcareous strata, most of which are gray micaceous limestones, others coarse-grained white limestone, others again dark blue limestones, while sandstones occur sparingly. Still higher follow 7500 feet of green diorite slates, mica slates, and hornblende rock; and, above all, is a granitic gneiss, estimated at 2100 feet. The nature of the beds in Hastings differs from those near the Ottawa, in being more varied, and in slates occupying the place of the gneiss. The aggregate thickness of the section is 20,000 feet, of which about 4360 is calcareous, showing a rather less proportion of limestone than in the Ottawa section. These sections by no means exhibit the maximum thickness of limestone in this series, but enough has been said to show how abundant calcareous matter was in the earliest strata known. Can it be possible, or even probable, that nearly a vertical mile of rock has been accumulated through the agency of organic life, seeing that not a single unquestionable fossil has been found in these old sea bottoms? To both alternatives we should be inclined to answer in the affirmative for various reasons; but as these reasons do not cover the whole question, there is left a margin for doubt.

The Laurentian limestones are in a highly degree crystalline, and in some places, where they are made of aggregations of large calcspar crystals, they may be said to be crystallized. This condition would account in part for the obscurity of their fossil contents, if they ever contained any. In this respect they resemble many crystalline limestones of a far more recent age, in which the organic remains are obscure, but which are known to contain evidence of contemporary organic life. Like some of these newer limestones, those of the Laurentian series present appearances which in the newer rocks are considered to be the remains of certain classes of animals. Thus the Grenville and other limestones contain fragments which have all the appearances which occur in the débris of crinoidal, coralline, and molluscan hard parts in the more highly crystalline Silurian limestones. In the Silurian beds, however, perfect organic remains have been met with, whereas in the Laurentian nearly everything that has been seen has appeared to be fragmentary. The exception implied by the use of the word nearly has reference to the peculiar structure which is found well developed in the limestone at Grenville, Burgess, Tudor, Madoc, and elsewhere, and which we may term *eozoonal;* but this structure, be it observed, occurs in the least altered parts of the limestone. This structure has been thus described by Sir W. Logan: "The zone of Grenville limestone is in some places about 1500 feet thick, and it appears to be divided for considerable distances into two or three parts by very thick bands of gneiss. One of these occupies a position towards the lower part of the limestone, and may have a volume of between 100 and 200 feet. It is at the base of the limestone that the fossil occurs. This part of the zone is largely composed of great and small irregular masses of white crystalline pyroxene, some of them twenty yards in length, by four or five wide; and they appear to be confusedly placed one above another, with many ragged interstices, and many smooth, worn, rounded, large and small pits and subcylindrical cavities, some of them pretty deep. The pyroxene, though it appears compact, presents a multitude of small spaces, consisting of carbonate of lime, and many of them show minute structures similar to that of the fossil. These masses of pyroxene may characterize a thickness of about 200 feet, and the interspaces among them are filled with a mixture of serpentine and carbonate of lime. In general, a sheet of pure dark green serpentine invests each mass of pyroxene, the thickness of the serpentine varying from the sixteenth of an inch to several inches, rarely exceeding half a foot. This is followed in different spots by parallel, waving, irregularly alternating plates of carbonate of lime and serpentine, which become gradually finer as they recede from the pyroxene, and occasionally occupy a total thickness of from five to six inches. These portions constitute the unbroken fossil, which may sometimes spread over an area of about a square foot, or perhaps more. Other parts, immediately on the outside of the sheet of serpentine, are occupied with about the same thickness of what appears to be the ruin of the fossil broken up into a more or less granular mixture of calcspar and serpentine, the former still showing minute structure; and on the outside of the whole a similar mixture appears to have been swept by currents and eddies into rudely parallel and curving layers, the mixture becoming gradually more calcareous as it recedes from the pyroxene. Sometimes beds of limestones of several feet in thickness, with the green serpentine more or less aggregated into layers, and studded with isolated lumps of pyroxene, are irregularly inter-stratified in the mass of rock; and less frequently there are met with lenticular patches of sandstone, or granular quartzite, of a foot in thickness and several yards in diameter, holding in abundance small disseminated leaves of graphite. The general character of the rock connected with the fossil produces the impression that it is a great foraminiferal reef, in which the pyroxenic masses represent a more ancient portion, which, having died, and having become much broken up, and much worn into cavities and deep recesses, afforded a seat for a new growth of *Foraminifera,* represented by the calcareo-serpentinous part. This in its turn became broken up, leaving in some places uninjured portions of the general form. The main differences between this foraminiferal reef and more recent coral reefs seem to be that, while with the latter are usually associated many shells and organic remains, in the more ancient one the only remains yet found are those of the animal which built the reef." When examined more minutely with the microscope, these patches present so close a resemblance to the by no means simple arrangement of the calcareous test of some *Foraminifera,* that it is very difficult to deny that they are of organic origin, and not to admit, with Messrs. Dawson, Carpenter, and others, that they are the remains of a true species, the *Eozoon Canadense.* The Laurentian rocks comprise many of the varieties of limestone which are developed in more recent formations. Some are coarse-grained, others saccharoidal, but it is rare that they acquire so fine a texture as is implied by the term compact. The colours are varied, ranging from pure white to dull white, barred and streaked with grey or black or blue or red. Some bands are wholly tinged with the last-mentioned colour, except red, which is only found in small patches. The grey and black varieties owe their colour to the presence of disseminated mica and graphite, minerals which are associated together, and which are present in greater or less abundance in almost all the Laurentian limestones. The graphite usually occurs in scales and nests, and, like the mica, is usually arranged in parallel bands. Iron pyrites frequently accompanies them, and is also, as indeed are nearly all the minerals in these limestones, arranged in layers. These minerals evidently represent the bituminous, argillaceous, and ferruginous matters which are so commonly found in the most fossiliferous limestones of more recent age. This arrangement indicates a stratified condition of the limestone, but this is more clearly shown by the way in which these rocks are associated with gneiss. The limestones are, in the great majority of cases, interstratified amongst gneiss; frequently the two sets of strata are much contorted into folds and loops, but however complicated the twisting, the gneiss and limestone bands occur in parallel lines; so that there is little doubt they represent a well-defined system of stratification.

In the Upper Laurentian strata there are two or more bands of limestone, but the stratigraphical relations of the beds have not been fully developed.

In Bohemia, as also in Bavaria, the oldest recognisable stratified rocks are immense masses of gneissose and schistose rocks. The limestones are far less developed than in Canada; but in the crystalline limestones of Bohemia eozoonal structure has been detected.

The Huronian series has been recognised as yet in but few countries. In Canada it is about 18,000 feet from top to bottom, but the great bulk consists of quartzites and conglomerates. There is one calcareous zone 300 feet thick in the lower half; and a second, about 400 feet thick, in the upper half, but in the latter the limestone is associated with slates and sandstones. On the whole, the proportion of limestone to other rocks is about as 1 to 36—far less than in the preceding era. In Norway, Huronian limestones are associated with gneiss, but it is less abundant in that country than in Canada.

In the Cambrian series, as understood by Sir R. I. Murchison, limestones are less abundant than in the preceding Huronian series; indeed, limestones are exceedingly rare in the known exposures of rocks of this age, although they comprise in the aggregate many thousand feet in thickness. The Cambrians of Wales are estimated at 26,000 feet.

It is not until the Cambrian strata have been deposited that limestones again become abundant in America and Europe. In the former country the Potsdam sandstone is succeeded by another sandstone which is highly charged with calcareous matter, hence termed the calciferous sandstone, and which ushers in the long succession of Silurian limestones with their profusion of organic remains. In the eastern portion of the United States the calciferous sandstone presents its typical character, but towards the west the sandstone is largely interstratified with magnesian limestones. In the lower Silurian of the United States nearly all the limestones are more or less magnesian. In Pennsylvania this part of the series comprises 7500 feet of strata, of which about 6000 feet is calcareous; so that limestones form fully three-fourths of the stratified deposits, shales and slates making up most of the remainder. In Michigan the lower Silurian period is represented by about 50 feet of strata, nearly all limestone. In Iowa the limestones form 350 feet out of a total of about 500 feet. In Illinois they have about the same thickness, and bear nearly the same proportion to other kinds of rocks. In Missouri there are scarcely anything but limestones, which are accumulated to a thickness of nearly 700 feet. In Tennessee there are about 700 feet of limestones associated with about 1500 feet of shales. In the British Isles limestones were by no means so rife as in the United States during this period; indeed, generally no limestone is to be found in this part of the series until some thousands of feet of non-calcareous strata have been traversed. Thus, in Westmoreland the lowest limestone met with is about 14,000 feet above the base of the series; and the Bala limestone, the lowest in the Silurian of Wales, is underlain by upwards of 10,000 feet of sandstones, slates, and volcanic rocks, and is itself of inconsiderable thickness. There is, then, a marked contrast in the development of limestones during this period in the British and American areas.

We will next turn to the upper Silurian strata. In Pennsylvania the limestones constitute some 700 feet out of rather more than 7000 feet of strata, or in the proportion of 1 to 10; and by far the most of this is accumulated at the summit of the series. In Michigan there are 185 feet of strata, mostly limestones. In Iowa limestones form the whole series, with the exception of a few shale partings, and are nearly 1000 feet thick. In Missouri also, there are little else than limestones, the volume of the series being 250 feet. In Tennessee the upper Silurian is represented by about 1500 feet of beds, of which 300 feet at the most are limestone. Reckoning the Llandovery formation as part of the upper Silurian series, there are nearly 8000 feet of strata of this age in the British Isles, of which not more than a few hundred feet are calcareous.

The Devonian strata of Pennsylvania are estimated to be 14,300 feet thick, consisting almost entirely of non-calcareous sediments. The limestones are very scanty, but they are massed together in that part of the series which is believed to represent the middle Devonian period. There are upwards of 700 feet of shales and sandstones more or less calcareous beneath the massive blue limestone, 80 feet thick, which is referred to the corniferous period, when limestone accumulation was in the ascendant in the United States. Above it are shales, sandstones, and slates piled one above another for more than 12,000 feet, in which the calcareous matter is disseminated, not aggregated into beds. In Michigan the lower Devonian is represented by a conglomerate three feet thick; the middle Devonian by 354 feet of limestones; and the upper Devonian by 265 feet of strata, of which the larger portion consists of limestones. In Iowa the Devonian series consists entirely of limestones, but the lower portion is unrepresented; the middle Devonian comprises about 50 feet of grey limestone; and the upper Devonian 100 feet of magnesian limestones, and probably 100 feet of siliceous shales, which are calcareous in parts. In Illinois, Devonian strata are largely limestones which are 120 feet in thickness, and are associated with some 90 feet of arenaceous and argillaceous beds. In Missouri limestones also prevail, there being upwards of 375 feet of them. In Tennessee the Devonian series is represented by an inconsiderable thickness of slates only.

In the British Isles the Devonian strata consist of enormous thicknesses of sandstones in Scotland and Wales, reaching in the latter country to more than 10,000 feet, while the limestone is restricted to a few thin bands. The calcareous beds increase in frequency and proportion towards the south, and are most concentrated in the strata representing the middle part of the Devonian period [DEVONIAN GROUP, E. C. S.]. In Belgium there is the still thicker Givet limestone, and further south the Eifel limestone, both of which are usually referred to the middle Devonian period.

Of the limestones deposited during the carboniferous period in North America and Western Europe we need say nothing here, as details are given under CARBONIFEROUS SYSTEM, E. C. S. col. 201, *et seq.*

From this sketch, incomplete as it is, it may be considered as probable that limestones were accumulating during the whole of the palæozoic period, but interruptedly as regards geographical areas. Hence one of the most important desiderata in geological science is to trace out the continuous succession of limestones, indicating the shifting boundaries of the area of limestone deposition from time to time; the elevations and depressions of the earth's surface, the deflection of currents, and the other causes which influenced such changes; as also the accompanying variations in the phenomena of organic life, more especially as regards its distribution. When that is done palæontologists will be able to form a clear conception of the zones, which are now so much resorted to in stratigraphical descriptions. Then too, perhaps, a rough chronological table may be drawn up, such as would greatly facilitate the estimates of the duration of geological periods. As an example we may refer to Professor Dana's "time-ratios" for the palæozoic periods, as represented by the Appalachian deposits. He groups them as fragmental and calcareous rocks, as shown below.

	Fragmental rocks.	Limestones.
Silurian. . .	15,160 feet.	6,800 feet.
Devonian . .	14,300 „	100 „
Carboniferous.	14,600 „	125 „

When the strata of apparently the same period are compared together in several regions the limestones are generally from one fifth to one-tenth the thickness of the fragmental beds; that is, while one foot of limestone is being formed, from five to ten feet of clastic or fragmental strata are deposited elsewhere. Taking the ratio to be as five to one, and supposing the strata of each period were entirely limestones, the following will be the greatest thicknesses of limestone belonging to each. For the Silurian period, 9830 feet; the Devonian, 2960 feet; and for the carboniferous period, 3035 feet. This would imply that reckoning the carboniferous as a period of a certain number of years, the Devonian was of about equal duration, while the Silurian corresponds to nearly three such periods. On the same supposition the Cambrian would have extended over two periods; the Huronian to one; and the Laurentian to rather more than three periods.

The writer is unable to give the relative thicknesses of the calcareous and non-calcareous strata more recent than the palæozoic age, but, judging from impressions acquired in the course of reading, not directed to this question, would estimate the total thickness at about 27,000 feet, of which not more than 2000 feet consists of limestones, so that the whole neozoic epoch may be regarded as about equivalent to two periods.

If limestones have been forming continuously throughout all geologic time, and if a continuous series ever be traced, its vertical thickness will probably turn out to be about 40,000 feet, exclusive of that which represents the gaps, such as those between the primary and secondary, between the secondary and tertiary strata, and others, which would possibly require an addition of at least 10,000 feet to the estimate.

We have said so little of the physical character, chemical composition, included minerals, modes of formation, and metamorphoses of the many varieties of limestones, and our space precludes further details, that we refer the reader to a few of the authorities which will supply him with such information. They are: Bischoff, 'Chemical and Physical Geology'; Haughton, 'Manual of Geology'; Jukes, 'Manual of Geology'; Lyell, 'Elements of Geology'; Dana, 'Manual of Geology'; Zirkel, 'Lehrbuch der Petrographie'; Delesse, 'Études sur le Metamorphisme des Roches'; Logan, 'Geology of Canada,' 1863; Cotta, 'Rocks Classified and Described'; Leymerie, 'Elements de Mineralogie'; Ramsay and others, 'Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology'; Roth, 'Gesteinslehre'; Naumann, 'Lehrbuch der Geognosie.'

LOBOSA. [AMŒBA, E. C. S.; FORAMINIFERA, E. C. S.]

LONDON CLAY [E. C. vol. iii. col. 527]. Under EOCENE, E. C. S., a rapid *résumé* is given of the principal eocene strata of England, a passing notice only being given to the London clay. It was there pointed out how decided is the lithological contrast between the bounding strata of the secondary and tertiary groups of this country; and that such distinctive features coincided with a thorough revolution in the physical conditions of the area. At the time when the highest chalk was deposited, Southern England was the site of an oceanic area many miles from land; while the Thanet beds and the Woolwich and Reading series have evidently been formed within a few miles of some old continental coast, and in that part of an ocean where the waters were shallow. The Woolwich series represent the accumulations of a large river not far from where it entered the sea. The London clay is in direct sequence to this series, and seems to have been formed from a river which may have been the same as that which acted as carrier for the underlying beds, or if such was not the case, a river which flowed over the same land as the previous one, and nearly in the same direction. The London clay, however, indicates deeper water, so that it would seem either that the land, or rather the oceanic bottom near land, had been gradually sinking during this period, or that the currents had become much weaker, and were able to carry the finer particles of sedimentary matter to a shorter distance. Without going into the minute details and lengthy discussions which would be requisite to demonstrate from what direction this river of the London clay period flowed, the lay of the land which it drained, and its approximate size, we may ask the reader to forget entirely the relative positions of land and sea at the present time, and to imagine a continent stretching far away to the west and occupying a large portion of the North Atlantic ocean; to further imagine that the eastern coast line extended northerly along a latitude nearly coinciding with that of the present eastern counties, and that this line trended S.W. from Norfolk to Berkshire and Devonshire; and then S.E. across the Channel, through, say the departments of Côtes du Nord, Indre and Cher; and then across the central parts of Europe. It is believed that this old tertiary river flowed from the S.W. into a bay formed by the south-eastern counties of England, the north-eastern departments of France, and the intervening channel; and that the London clay was formed in the deeper part of this bay, and some eighty or more miles from the mouth of the river.

Next let us endeavour to trace out the area over which the London clay was originally spread; and as a step towards this end consideration must first be given to those places where the London clay is conformably interstratified between the Woolwich beds below and the Bagshot series above. At Southampton the London clay is 320 feet thick; at Whitecliff bay, Isle of Wight, it is nearly 300 feet; at Chobham, in Surrey, it is about 400 feet, and a similar thickness occurs near Windsor; at Hampstead Hill and south to Regent's Park, the thickness is about 420 feet; at Wimbledon it is about 400 feet; at High Beech, in Essex, it is probably somewhat less than 440 feet; around Havering and Brentwood it averages 450 feet; near Sheppey the thickness is about 470 feet; near Rayleigh it is nearly the same as at Sheppey; at Cassel, Nord department, France, it is about 400 feet; near Douai, further S.S.E., the thickness has diminished to about 200 feet; and between the last-mentioned locality and Montdidier, Oise department, the clay has thinned out, its place being occupied by a gap. From these measurements it may be concluded that this deposit spread uniformly over a large portion of the bay, the supposed form of which has been outlined above; gradually expanding from about 300 feet in Hampshire to 400 feet in Surrey, Berkshire, and Middlesex, and to nearly 500 feet in Essex and Kent; and thinning out towards the east, as in north-east France, and the north-west corner of Belgium. Since the periods of the deposition of the London clay and of the Bagshot sands the area of this old bay has been subjected to so many alterations, both of upheaval and depression, of denudation and of sedimentary deposit, that we now find the London clay in a few patches only, forming portions of the London, Hampshire, Paris, and Belgian basins, and in each of these basins its upper surface has been so scored, excavated, and exposed, that great difficulty is experienced in detecting its former lenticular outline. That part of the London clay which now remains is only a small portion, whether vertically or horizontally, of what it once was; the great bulk of it has been swept away. In and around London, and along the lower portion of the Thames valley farther east, the depressions have been for the most part cut out of the London clay; the Hampstead, Highgate, Wimbledon, Langdon, and other hills, indicate the depth of the excavation, since the Lea, Thames, and other streams flow on a bottom of London clay. These hills owe their height far more to inequality of erosion than to the undulations of the strata. The chalk area of Kent, Surrey, Sussex, Hampshire, and the English Channel, is an area of elevation from which the London clay has been totally removed. The water of the English Channel itself occupies the site or place of the lower portion of the clay; and at Calais the shelving shore of the sea and the lowland up to Cassel is formed by it. If we consider the immense spaces from which the clay has been removed, we shall be impressed with the immense amount of work which denuding agents have done in tertiary times; but the magnitude of the result is still greater than is implied above, for the beds underlying the London clay have been themselves cut through or washed away to a thickness of several hundred feet. A portion of this denudation no doubt occurred before the London clay period, but not a little must have taken place since. Thus the hollow represented by the Wealden valley has been entirely formed since the London clay was laid down.

Having regard to the facts already stated it may be surmised, with some approach to accuracy, that the river of the London clay period was far larger than the present Thames, probably as large as the Danube, and that the land from which it derived the detritus it carried, and which would be the basin of this river, has almost, if not quite, wholly vanished. The Danube stretches nearly west and east over twenty degrees of longitude, and a similar river having its mouth off Devonshire, would stretch almost as far as the Azores.

Having roughly mapped out the ground it would be desirable next to examine the clay more minutely with a view to detecting those minor circumstances which constitute the habitats of species, and which cause zoological differences in various parts of the same sea bottom. But this task is very difficult, since the clay retains a remarkably uniform character wherever met with; the most marked differential lithological point being, that in those parts where the original development of the clay was least, sand occurs somewhat sparingly. It is very likely that a special investigation would reveal appreciable differences in the clay of different levels and at different spots, since the fossils generally, and certain species in particular, are found to prevail on definite horizons. In the London district each horizon occupies, stating the matter very roughly, about 100 feet. In order that these horizons may not be regarded as being precisely defined, or as being equally applicable to all parts of the London clay area, we give Mr. Prestwich's remarks respecting this point. "Confining ourselves to the London district, it would appear that although a great proportion of the fossils range at intervals vertically throughout the London clay, yet their development is very different in different zones, being abundant in some and scarce in others, whilst each zone is further marked by a few characteristic species, thus forming distinct although nearly related groups; that plant remains occur sparingly throughout the mass of the London clay, but that their chief development is in the uppermost, or perhaps superadded beds in the eastern area, in which also are entombed the great bulk of the reptilian and fish remains; that a profusion of mollusks indicating waters of a more moderate depth characterise the second descending stage; that deeper sea forms prevail in the third stage in the eastern area, but are replaced by a shallower water fauna, more nearly allied to the fossils of the second stage as we proceed westward; and that the same changes take place also in the fourth and lowest stage, many of the forms of the upper divisions being common to it in the westward area where the sea was evidently shallow, whilst eastward we have indications of the maximum depth of the London clay sea with a very scanty fauna of deep sea forms." This harmonizes well with the view that the clay was deposited in a bay connected with a broad estuary. The bottom of the bay would slope from S.W. to N.E. If the depression proceeded faster in the eastern than in the western part of the bay we should expect to find a greater community between the clay generally in the west, and the lowest zone in the east. Much of the difference noted may be due to variations in the depths, and the similarities may be in great measure owing to the species having lived under the same conditions with respect to depth and other circumstances. "It must not, however," Mr. Prestwich continues, "be supposed that the fossils are dispersed either vertically or horizontally with any uniformity as to numbers; although, as before mentioned, certain zones are characterized by certain groups of organic remains, yet the fossils tend to occur in greater or less abundance in certain beds. This is especially the case in the lower zone, which is frequently almost totally unfossiliferous; the third zone likewise is often marked by the absence of fossils, and so again with the upper zone; the fossils appear more permanent in the second zone. These zones are necessarily artificial, as no actual division exists, and the organic remains and mineral characters are continuous; but they serve to mark the distinct conditions of the fauna and flora at particular periods, and show the prevalence generally of like forms on the same levels; they are not, however, to be taken by any means as constant, but merely as local centres for convenient reference and grouping."

In illustration of his remarks Mr. Prestwich has drawn up lists of most of the described species arranged according to the zones, which lists we append below, to which we have added an enumeration of some of the species whose precise horizon we are not able to give, including an amended list of the *Foraminifera* by Professor T. Rupert Jones. We have also given a list of the fossils found in the basement bed of the London clay. The asterisks indicate the most abundant and characteristic species of mollusca. The first or uppermost zone varies in thickness from about 70 feet in the western portion of the London basin to 150 feet in the east. Fossils occur in its exposures in the cliffs of Sheppey and Southend; at Brentwood Hill; and at Egham Hill; but the following list applies more particularly to the Isle of Sheppey:—

AVES.

Halcyornis toliapicus. Owen.
Lithornis vulturinus. Owen.
L. (?) emuinus. Bowerb.

REPTILIA.

Chelone breviceps. Owen.
C. convexa. Owen.
C. cuneiceps. Owen.
C. latiscutata. Owen.
C. longiceps. Owen.
C. subcarinata. Owen.
C. subcristata. Owen.
Emys bicarinatus. Bell.
E. Comptoni. Bell.
E. Delabechei. Bell.
E. lævis. Bell.
E. testudiniformis. Owen.
Platemys Bowerbankii. Owen.
P. Bullockii. Owen.
Trionyx pustulatus. Owen.
Crocodilus champsoides. Owen.
C. toliapicus. Owen.
Palæophis toliapicus. Owen.

PISCES.

Acestrus ornatus. Agassiz.
Acipenser toliapicus. Ag.
Ætobatis irregularis. Ag.
Æ. subarcuatus. Ag.
Ampheristus toliapicus. Kön.
Auchenilabrus frontalis. Ag.
Bothrosteus minor. Ag.
Brachygnathus tenuiceps. Ag.
Brychetus Mulleri, Ag.
Calopomus porosus. Ag.
Carcharodon angustidens. Ag.
C. subserratus. Ag.
Cœlocephalus salmoneus. Ag.
Cœloperca latifrons. Ag.
Cœlopoma Colei. Ag.
C. læve. Ag.
Cœlorhynchus rectus. Ag.
Cybium macropomum. Ag.
Elasmodus Hunteri. Egert.
Eurygnathus cavifrons. Ag.
Glyphis hastalis. Ag.
Goniognathus coryphænoides. Ag.
G. maxillaris. Ag.
Gyrodus lævior. Ag.
Halecopsis lævis. Ag.
Hypsodon oblongus. Ag.
H. toliapicus. Ag.
Labrophagus esocinus. Ag.
Lamna compressa. Ag.
L. elegans. Ag.
L. Hopei. Ag.
L. verticalis. Ag.
Laparus alticeps. Ag.
Loxostomus mancus. Ag.
Megalops priscus. Ag.
Merlinus cristatus. Ag.
Myliobatis acutus. Ag.
M. canaliculatus. Ag.
M. Colei. Ag.
M. Dixoni. Ag.
M. goniopleurus. Ag.
M. gyratus. Ag.
M. heteropleurus. Ag.
M. jugalis. Ag.
M. laternalis. Ag.
M. nitidus. Ag.
M. Oweni. Ag.
M. punctatus. Ag.
M. striatus. Ag.
M. toliapicus. Ag.

Myripristis toliapicus. Ag.
Notidanus serratissimus. Ag.
Otodus macrotus. Ag.
O. obliquus. Ag.
Pachycephalus cristatus. Ag.
Percostoma angustum. Ag.
Periodus Königii. Ag.
Phalacrus cybioides. Ag.
Phasganus declivis. Ag.
Phyllodus irregularis. Ag.
P. marginalis. Ag.
P. medius. Ag.
P. planus. Ag.
P. polyodus. Ag.
P. toliapicus. Ag.
Pisodus politus. Owen.
Podocephalus nitidus. Ag.
Pomophractus Egertoni. Ag.
Pristis bisulcatus. Ag. (?).
Psaliodus compressus. Ag.
Ptychocephalus radiatus. Ag.
Pycnodus toliapicus. Ag.
Rhinocephalus planiceps. Ag.
Rhipidolepis elegans. Ag.
Rhonchus carangoides. Ag.
Rhynchorhinus branchialis. Ag.
Sciænurus Bowerbanki. Ag.
S. crassior. Ag.
Scombrinus crassidens. Ag.
S. priscus. Ag.
Teratichthys antiquitatis. Kön.
Tetrapterus priscus. Kön.

MOLLUSCA.

Cephalopoda.
Belosepia sepioidea. Blain.
* Nautilus centralis. Sow.
* N. imperialis. Sow.
N. regalis. Sow.
N. urbanus. Sow.
* N. (Aturia) zic-zac. Sow.

Gasteropoda.
Actæon simulatus. Sow.
Ancillaria.
Aporrhais Sowerbii. Mant.
Buccinum junceum. Sow. (?)
* Bulla attenuata. Sow.
Cancellaria quadrata. Sow.
Cassidaria nodosa. Brand.
C. striata. Sow.
* Cerithium Charlesworthii. Prest.
* Conus concinnus. Sow.
Corbula.
Cypræa oviformis. Sow.
Dentalium nitens. Sow.
* Fusus bifasciatus. Sow.
F. coniferus. Sow.
Murex cristatus. Sow.
M. spinulosus. Desh.
* Natica labellata. Lam.
* Pleurotoma prisca. Sow.
P. rostrata. Sow.
* Phorus extensus. Sow.
Pyrula tricostata. Desh. (?)
P. angulata. Edw.
* Rostellaria lucida. Sow.
Scalaria reticulata. Sow.
* Solarium patulum. Sow.
S. canaliculatum. Lam.
Terebra striata.
Triton.
* Turritella imbricataria. Lam.
Voluta nodosa. Sow.

Lamellibranchiata.
Arca.
* Astarte rugata. Sow.
* Avicula papyracea. Sow.
A. media. Sow.
Cardita.
* Cardium nitens. Sow.
* Cryptodon Goodhalli. Sow.
Cyprina planata, var. Sow. (?)
C. nana. Sow.
C. obliqua. Desh.
Isocardia sulcata. Sow.
Modiola.
* Neæra inflata. Sow.
Nucula amygdaloides. Sow.
N. Bowerbankii. Sow. (?)
Ostrea.
* Pectunculus decussatus. Sow.
Pinna arcuata. Sow. (?)
Syndosmya splendens. Sow.
* Teredo antenautæ. Sow.
Teredina personata. Lam.

Brachiopoda.
* Terebratulina striatula.

ANNULOSA.

Crustacea.
Archæocarabus Bowerbanki. M'Coy.
Basinotopus Lamarckii. Desm.
Hoploparia Belli. M'Coy.
H. gammaroides. M'Coy.
Zanthopsis bispinosa. M'Coy.
Z. hispidiformis. Schloth.
Z. Leachii. Desm.
Z. nodosa. M'Coy.
Z. unispinosa. M'Coy.
Annelida.
Serpula.
Vermicularia bognoriensis. Mant.
Echinodermata.
Astropecten armatus. Forbes.
A. (?) Colei. Forbes.
A. crispatus. Forbes.
Cœlopleurus Wetherellii. Forbes.
Goniaster Stokesii. Forbes.
G. marginatus. Forbes.
G. tuberculatus. Forbes.
Hemiaster Bowerbankii. Forbes.
H. Prestwichii. Forbes.
Pentocrinus subbasaltiformis. Mill.

CŒLENTERATA.

Actinozoa.
Graphularia Wetherelli. M.-Edw.
Paracyathus brevis. M.-Edw.
P. caryophyllus. Lam.
Trochocyathus sinuosus. Brong.

PLANTÆ.

Lycopodiaceæ.
Lycopodites squamatus. Brong.
Coniferæ.
Callitrites. 4 sp.
Frenelites. 4 sp.
Solenostrobus. 5 sp.
Aurantiaceæ (?).
Wetherellia variabilis. Bow.
Cucurbitaceæ.
Cucumites variabilis. Bow.
Leguminosæ.
Faboidea. 25 sp.
Leguminosites. 18 sp.
Xulionosprionites. 2 sp.
Malvaceæ.
Hightea. 10 sp.
Nipaceæ.
Nipadites. 12 sp.
Proteaceæ.
Petrophiloides oviformis. Bow.
Sapindaceæ.
Cupanoides. 8 sp.
Tricarpellites. 7 sp.

The second zone varies from 80 feet in the west to 100 feet in the east. The principal fossiliferous localities are Margaretting street; near Chelmsford; Highgate archway, to which place the following list more especially applies; Wandsworth Common; Newnham; Clewet's Green.

REPTILIA.

Vertebræ of Palæophis (?), and some small teeth, probably reptilian.

PISCES.

Carcharodon.
Cœlorhynchus.
Lamna elegans. Ag.
Myliobatis Dixoni. Ag.
Notidanus.
Otodus obliquus. Ag.

MOLLUSCA.

Cephalopoda.
Belemnosis plicata. Edw.
Beloptera Levesquei. D'Orb.
Belosepia sepioidea. Blain.
* Nautilus imperialis. Sow.
N. Sowerbyi. Weth.
N. zic-zac. Sow.
Gastcropoda.
Actæon crenatus. Sow.
* A. simulatus. Sow.
Ancillaria.
Aporrhais Sowerbii. Mant.
Buccinum junceum. Sow.
* Bulla attenuata. Sow.
* Cancellaria læviuscula. Sow.
* Cassidaria nodosa. Brand.
* C. striata. Sow.
Cerithium concinnum. Char.

* Conus concinnus. Sow.
Cypræa oviformis. Sow.
* Dentalium nitens. Sow.
Eulima subulata. Sow.
Fusus bifasciatus. Sow.
* F. coniferus. Sow.
* F. curtus. Sow.
F. complanatus. Sow.
F. interruptus. Sow.
F. porrectus. Brand.
* F. trilineatus. Sow.
F. tuberosus. Sow.
Hipponyx.
* Melania.
Mitra pumila, Sow.
* Murex coronatus. Sow.
M. cristatus. Sow.
M. frondosus. Sow.
M. minax. Brand.
M. spinulosus. Desh.
* Natica labellata. Lam.
N. hantoniensis. Sow.
N. sigaretina. Sow.
Odostomia.
* Phorus extensus. Sow.
Pyramidella.
Pyrula angulata. Edw.
Ringicula turgida. Sow.
Rostellaria lucida. Sow.
R. macroptera. Lam.
Pleurotoma acuminata. Sow.
* P. colon. Sow.
* P. comma. Sow.
P. fusiformis. Sow.
P. plebeia. Sow.
P. rostrata. Sow.
P. semicolon. Sow.
P. Waterkeynii. Nyst.
P. Volgeri. Phil.
Scalaria reticulata. Sow.
S. undosa. Sow.
Skenea (?).
Solarium canaliculatum. Lam.
* S. patulum. Sow.
Sigaretus canaliculatus, Sow.
Triton fasciatus. Edw.
Typhis muticus. Sow.
Turritella imbricataria. Lam.
T. scalaroides. Sow.
Volvaria (?).
* Voluta nodosa. Sow.
Lamellibranchiata.
Anomia lineata. Sow.
Anatina (?).
Arca impolita. Sow.
Astarte rugata. Sow.
* Avicula media. Sow.
A. papyracea. Sow.
Cardium nitens. Sow.
Cardita (?).
* Corbula globosa. Sow.
C. cardiiformis. Edw.
* Cytherea obliqua.
Cryptodon Goodhalli. Sow.
Lucina.
Modiola depressa. Sow.
* M. elegans. Sow.
M. subcarinata. Sow.
Neaera inflata. Sow.
Nucula minima. Sow.
N. trigona. Sow.
Panopæa intermedia. Sow. ?
* Pecten corneus. Sow.
Pectunculus decussatus. Sow.
Pholadomya (?)
Pinna affinis. Sow.
P. arcuata. Sow.
Sanguinolaria compressa. Sow.
* Solen affinis. Sow.
Syndosmya splendens.
Teredina personata. Lam.
* Teredo antenautæ. Sow.
Brachiopoda.
Lingula tenuis. Sow.
Polyzoa.
Flustra.
Eschara.
Cellepora.
Crisia.

ANNULOSA.

Crustacea.
Archæocarabus (?).
Basinotopus.
Scalpellum quadratum.
Zanthopsis nodosa. M'Coy.
Z. Leachii. Desm.

Annelida.
Ditrupa incrassata. Sow.
Serpula heptagona. Sow. (?)
S. crassa. Sow.
Vermicularia bognoriensis. Mant.
Echinodermata.
Cœlopleurus Wetherellii. Forbes.
Hemiaster (?).
Ophiura Wetherelli. Forbes.
Pentacrinus Sowerbii. Weth.

Cœlenterata.

Actinozoa.
Graphularia Wetherellii. M.-Edw.

Protozoa.

Foraminifera.
Cristellaria.
Dentalina.
Robulina.
Rosalina.
Rotalina.
Truncatulina.

Plantæ.

Some species of Nipadites, and a few fruits.

The third zone averages about 100 feet in thickness in the west, and 140 feet in the east. Fossils occur in it in the cliffs between Herne Bay and Whitstable; at Colchester; at Chalk Farm, Primrose Hill, Copenhagen Fields, Islington, Hornsey, all of which places are in the London suburbs; at Colney Hatch; Kew; Brentford; Whetstone; and Cuffell.

Aves.

Sternum of a small wader.

Reptilia.

Trionyx.

Pisces.

Ætobatis.
Lamna elegans. Ag.
Myliobatis.
Notidanus.
Otodus obliquus. Ag.

Mollusca.

Cephalopoda.
Belosepia.
* Nautilus centralis. Sow.
* N. regalis. Sow.
N. Sowerbii. Weth.
N. urbanus. Sow.
N. zic-zac. Sow.
Gasteropoda.
Actæon crenatus.
A. simulatus.
* Aporrhais Sowerbii. Mant.
Buccinum junceum. Sow.
Bulimus.
* Bulla attenuata. Sow.
Cancellaria læviuscula. Sow.
* Cassidaria striata. Brand.
C. nodosa. Sow.
Chemnitzia (?).
Cerithium Charlesworthii. Prest.
Cypræa Wetherellii. Edw.
* C. oviformis. Sow.
Dentalium anceps. Sow.
D. acuticosta. Desh. (?)
Eulima subulata. Sow.
Fusus carinella. Sow.
F. curtus. Sow.
* F. bifasciatus. Sow.
* F. interruptus. Sow.
F. coniferus. Sow.
F. trilineatus. Sow.
F. tuberosus. Sow.
* Natica labellata. Lam.
Murex cristatus. Sow.
Nerita globosa. Sow. (?)
Phasianella (?).
Phorus extensus. Sow.
* Pyrula Smithii. Sow.
* P. angulata. Edw.
P. tricostata. Desh.
* Pleurotoma acuminata. Sow.
P. plebeia. Sow.
Rissoa (?).
* Rostellaria lucida. Sow.
R. macroptera. Lam.
* Scalaria reticulata. Sow. (?)
* Solarium patulum. Sow.
Sigaretus canaliculatus. Sow.
Triton fasciatus. Edw.
Trivia.

Turritella (?) scalaroides.
T. imbricataria.
Typhis muticus. Sow.
Voluta elevata. Sow.
* V. protensa. Sow.
V. tricorona. Sow.
* V. Wetherelli. Sow.
Lamellibranchiata.
Anomia lineata. Sow.
Arca impolita. Sow.
A. nitens. Sow.
Astarte rugata, var.
Avicula media. Sow.
A. arcuata. Sow.
* Cardium plumsteadiense.
C. nitens. Sow.
* Corbula globosa. Sow.
C. regulbiensis. Mor.
* Cryptodon angulatum. Sow.
* C. Goodhalli. Sow.
* Cyprina planata. Sow.
Isocardia sulcata. Sow.
Lucina.
Modiola elegans. Sow.
* Neæra inflata. Sow.
* Nucula amygdaloides. Sow.
N. minima. Sow. (?)
N. Bowerbankii. Sow.
N. Wetherellii. Sow.
Ostrea.
Pecten duplicatus. Sow.
* Pinna affinis, Sow.
* Pholadomya margaritacea. Sow.
* Syndosmya splendens.
Teredo antenautæ.
Brachiopoda.
Terebratulina striatula. Sow.
Polyzoa.
Flustra crassa.

Annulosa.

Crustacea.
Archæocarabus.
Cythere. 3 sp.
C. (Bairdia) subdeltoidea. Müns.
C. (Cythereis) angulatopora? Reuss.
C. (C.) horrescens. Bosq.
C. (Cytherella) Münsteri. Roem.
C. (C.) ovata (?). Roem.
Hoploparia Bellii. M'Coy.
Zanthopsis Leachii. M'Coy.
Annelida.
Ditrupa plana. Sow.
D. incrassata. Sow.
Serpula prismatica. Sow.
S. trilineata. Sow.
Vermicularia bognoriensis. Mant.
Echinodermata.
Bourgueticrinus londinensis. Forbes.
Cainocrium tintinnabulum. Forbes.
Hemiaster Branderianus. Forbes.
Pentacrinus Oakshottianus. Forbes.
P. subbasaltiformis. Mill.
P. Sowerbii. Weth.

Cœlenterata.

Actinozoa.
Dasmia Sowerbii. M.-Edw.
Graphularia Wetherellii. M.-Edw.
Leptocyathus elegans. M.-Edw.
Mopsea costata. M.-Edw.
Stephanophyllia discoides. M.-Edw.
Turbinolia Prestwichii. M.-Edw.
Websteria crinoides. M.-Edw.

Protozoa.

Foraminifera.
Cristellaria.
Dentalina acuta. D'Orb.
D. Adolphina. D'Orb.
D. consobrina. D'Orb.
D. pauperata. D'Orb.
Glandulina.
Globulina.
Globigerina.
Marginulina Wetherellii. Jones.
Nodosaria affinis. D'Orb.
N. bacillum. Defr.
N. badenensis. D'Orb.
N. longiscata. D'Orb.
N. rustica. Jones.
Quinqueloculina.
Robulina.
Rotalina.
Spirillina.
Textularia carinata (?). D'Orb.
T. lævigata (?). D'Orb.
Triloculina.
Truncatulina.

Plantæ.

A few specimens of Nipadites, fruits, and seeds.

The fourth zone ranges from 50 to 90 feet in thickness, being thickest towards the east. It occurs at Harwich; Walton; Hedgerley; Old Basing; Sherfield; and Bognor, to which last place the following list more particularly refers.

Reptilia.

Chelone declivis. Owen.
Crocodilus sp.

Pisces.

Lamna subulata. Ag.
Otodus obliquus. Ag.

Mollusca.

Cephalopoda.
Nautilus imperialis. Sow.
* N. regalis. Sow.
* N. Sowerbii. Weth.
* N. centralis. Sow.

Gasteropoda.
Actæon simulatus.
* Aporrhais Sowerbii. Mant.
Buccinum (?).
* Cassidaria nodosa. Brand.
C. striata. Sow.
Fusus tuberosus. Sow.
F. nodosus. Sow.
Infundibulum trochiforme. Sow.
Littorina sulcata.
Natica hantoniensis. Sow.
N. microstoma. Sow.
* N. labellata. Lam.
* N. patula. Desh.
* N. sigaretina. Sow.
N. subdepressa. Mor.
Pleurotoma prisca.
Pseudoliva semicostata. Desh.
* Pyrula Smithii. Sow.
Solarium bistriatum. Sow.
* Turritella imbricataria. Lam.
T. scalaroides. Sow.
* Voluta denudata. Sow.

Lamellibranchiata.
* Anomia lineata. Sow.
* Oardita Brongniartii. Sow.
* C. quadrata. Sow.
Cardium plumsteadiense. Sow.
Corbula globosa. Sow.
Cultellus affinis. Sow.
Cyprina planata. Sow.
C. (?) nana. Sow.
Cytherea obliqua. Desh.
C. suberycinoides. Desh. (?)
* Modiola elegans. Sow.
M. simplex. Sow.
* Ostrea elephantopus. Sow.
O. cariosa. Desh.
* O. tabulata. Sow.
* Panopæa intermedia. Sow.
P. puella. Sow. (?)
* P. corrugata. Sow. (?)
* Pectunculus terebratularis. Lam.
* P. decussatus. Sow.
Pholadomya Dixoni. Sow.
P. Koninckii. Nyst.
P. margaritacea. Sow.
P. virgulosa. Sow.
Pholas Pechellii. Sow.
Pinna margaritacea. Sow. (?)
* P. affinis. Sow.
* Teredo antenautæ. Sow.
Teredina personata. Desh.
Thracia oblata. Sow.

Brachiopoda.
Lingula tenuis. Sow.

Annulosa.

Crustacea.
Hoploparia Bellii. M'Coy.
Scalpellum quadratum. Dixon.
Zanthopsis Leachii. M'Coy.

Annelida.
Ditrupa plana. Sow.
Serpula flagelliformis. Sow. (?)
Vermicularia bognoriensis. Mant.

The basement bed of the London clay has yielded fossils at Lane End, Holyport, Bray cut, Hedgerley, Cowcroft, Batchworth Heath, Bennett's End, Bushey, and Hampstead. The annexed list comprises species distributed amongst these localities, and is given by Whitaker in his memoir on the geology of Middlesex and the counties adjoining its western half.

Reptilia.

Lamna.

Pisces.

Bones, vertebræ, and scales.
Otodus.

Mollusca.

Gasteropoda.
Aporrhais Sowerbii. Mant.
Calyptræa trochiformis. Lam.
Cassidaria nodosa. Brand.
C. striata. Sow.
Fusus.
Natica hantoniensis. Sow.
N. labellata. Lam.
Pleurotoma.
Pyrula Smithii. Sow.
P. tricostata. Desh.
Rostellaria.
Scalaria.
Voluta.

Lamellibranchiata.
Cardium Laytoni. Mor.
C. nitens. Sow.
C. plumsteadiense. Sow.
Corbula regulbiensis. Mor.
Cyprina Morrisii. Sow.
Cyrena cuneiformis. Fer.
Cytherea obliqua. Desh.
C. orbicularis. Edw.
C. ovalis, var. (?) Sow.
Glycimeris (?).
Lithodomus (?).
Modiola elegans. Sow.
Nucula.
Ostrea bellovacina. Lam.
O. pulchra. Sow.
Panopæa intermedia. Sow.
Pectunculus brevirostrum. Sow.
P. plumsteadiansis. Sow.
Solen.
Tellina.

Brachiopoda.
Lingula tenuis. Sow.

Annulosa.

Annelida.
Ditrupa plana. Sow.

Plantæ.

A leaf and some fragments of wood.

The following species include a few whose horizon has not been indicated above, but which are found in the London clay.

Mammalia.

Coryphodon eoceænus. Owen.
Hyracotherium leporinum. Owen.

Reptilia.

Chelone crassicostata. Owen.
C. planimentum. Owen.

Mollusca.

Gasteropoda.
Bulimus ellipticus. Sow.
Cypræa Prestwichii. Edw.
Fusus angusticostatus.
F. bulbus. Brand.
Marginella bifidoplicata. Charlesw.
Pleurotoma abnormis. Edw.
P. cocciphora. Edw.
P. conica. Edw.
P. constricta. Edw.
P. dissimilis. Edw.
P. elegans.
P. fasciolata. Edw.
P. flexuosa. Münst. (?)
P. granata. Edw.
P. helix. Edw.
P. Koninckii. Nyst.
P. lævigata. Sow. (?)
P. Lehonii. Roualt.
P. lissa. Edw.
P. macrura. Edw.
P. parilis. Edw.
P. Prestwichii. Edw.
P. pupoides. Edw.
P. rotundata. Edw.
P. Selysii. De Kon.
P. simillima. Edw.
P. stena. Edw.
P. sulculosa. Edw.
P. symmetrica. Edw.

Pleurotoma tæniolata. Edw.
P. terebralis. Lam.
P. tereticosta. Edw.
P. teretrium. Edw.
P. tricincta Edw.
P. Wetherellii. Edw.
Pyrula nexilis. Lam. (?)
Rostellaria ampla. Brand.
Scalaria semicostata. Sow.
Turritella sulcifera. Desh.

Lamellibranchiata.

Anomia scabrosa. Wood.
Astarte donacina. Sow.
Cardium semigranulatum. Sow. (?)
Leda striata. Lam. (?)
L. prisca. Sow. (?)
Ostrea Bellovacina, var. pulchra. Sow.
O. gryphovinca. Wood.

ANNULOSA.

Crustacea.

Archæocarabus Bowerbankii. M'Coy.
Cyclocoristes pulchellus. Bell.
Cythere barbata. Sow.
C. scrobiculoplicata. Jones.
C. triangularis. Reuss.
C. (Cythereis) Bowerbankiana. Jones.
C. (Cytheridea) perforata. Reuss. 2 vars.
Cytherella compressa. Münst.
C. londinensis. Jones.
Dromilites Bucklandi. Edw.
D. Lamarckii. Desm.
Hoploparia gammaroides. M'Coy.
Scyllaridia Königi. Bell.
Thenops scyllariformis. Bell.
Trachysoma scabrum. Bell.

PROTOZOA.

Foraminifera.

Bulimina ovata. D'Orb.
B. (Bolivina) punctata. D'Orb.
Globigerina bulloides. D'Orb.
Lituola nautiloidea. Lam.
Miliola (Biloculina) depressa. D'Orb.
M. (Triloculina) oblonga. Mont.
M. (Quinqueloculina) triangularis. D'Orb.
Nodosarina (Cristellaria) cassis. Ficht and Moll.
N. (Crist.) crepidula. Ficht and Moll.
N. (Crist.) cultivata. Montf. (Includes Robulina.)
N. (Crist.) italica. Defr.
N. (Crist.) rotulata. Lam.
N. (Dentalina) acicula. Lam. (=D. acuta. D'Orb.)
N. (Dent.) acuticosta. Reuss.
N. (Dent.) brevis. D'Orb.
N. (Dent.) communis. D'Orb.
N. (Dent.) consobrina. D'Orb.
N. (Dent.) intermittens. Röm.
N. (Dent.) spinulosa. Mont. (Includes D. Adolphina. D'Orb.)
N. (Marginulina) lituus. D'Orb.
N. (Marg.) Wetherellii. Jones.
N. (Nodosaria) hirsuta. D'Orb.
N. (Nod.) ovicula. D'Orb. (Includes N. longiscata. D'Orb.)
N. (Nod.) pyrula. D'Orb.
N. (Nod.) radicula. D'Orb.
N. (Nod.) raphanus. Linn.
N. (Nod.) raphanistrum. Linn. (Includes N. affinis, D'Orb., and N. badenensis. D'Orb.)
N. (Vaginulina) linearis. Mont.
Planorbulina ammonoides. Reuss. (Includes Rosalina and Rotalina.)
P. Haidingeri. D'Orb.
P. Ungeriana. D'Orb.
P. (Truncatulina) lobatula. Walker and Jacob.
Pullenia sphæroides. D'Orb.
Pulvinulina elegans. D'Orb.
P. Micheleiniana. D'Orb.
Rotalia orbicularis. D'Orb.
Textularia abbreviata. D'Orb.
T. agglutinans. D'Orb.
T. carinata. D'Orb.
T. turris. D'Orb.
T. (Verneuilina) communis. D'Orb. (=Clavulina communis, D'Orb., and Nodosaria rustica. Jones.)
Trochammina incerta. D'Orb. (=Spirillina of some lists.)

These lists exemplify what may be almost termed a principle in palæontology, which principle is that while the law of development of organic beings regulates what classes or groups of species cannot occur in any given formation, it is local circumstances which determine what groups and what proportion of each group shall be represented by fossils. Thus taking these lists as our standard, although it must be remembered there are many other species not described, we arrive at the following analytical results. The number of species of each class is as follows :—

	Basement bed.	Zone 4.	Zone 3.	Zone 2.	Zone 1.
Rhizopoda	—	—	22	6	—
Actinozoa	—	—	7	1	4
Echinodermata	—	—	6	4	10
Annelida	1	3	5	4	2
Crustacea	—	3	9	5	9
Polyzoa	—	—	1	4	—
Brachiopoda	1	1	1	1	1
Lamellibranchiata	20	30	27	30	21
Gasteropoda	13	22	48	62	31
Cephalopoda	—	4	6	6	6
Pisces	2	2	5	6	80
Reptilia	1	2	1	2	18
Aves	—	—	1	—	3

Of the twenty-seven classes of animals, thirteen, or rather fourteen (for mammalia have left some remains) only are represented. There can be little doubt that the thirteen unrepresented classes were in existence at the time, but owing to their not being readily susceptible of fossilization, or to species belonging to them not having been buried in the London clay, relics of them are few or none. Of the represented classes none afford the maximum number of species in the basement bed. In zone 4 the lamellibranchs are as numerous as in any other, and keep up about the same abundance of species in zones 2 and 3, there being a slight decline in zone 1. No other class reaches its maximum in zone 4. In zone 3 the *Rhizopoda*, *Actinozoa*, *Crustacea*, and *Cephalopoda* attain the maximum. The *Rhizopoda* are far more numerous on this than on any other horizon ; the *Actinozoa* are somewhat more numerous ; while the *Crustacea* and *Cephalopoda* retain about the same numerical development at all higher levels. In zone 2 the *Polyzoa* and *Gasteropoda* are more fully developed than on any other, and in zone 1 the echinoderms, fishes, reptiles, and birds are better represented than anywhere below. These figures in themselves afford no safe indication as to what was the relative numerical importance of each class in the living world, or as to what was their relative numerical importance at different periods. Such points cannot be elucidated by the mere examination of lists, but require an investigation whose object is to ascertain, among other things, to what extent the conditions of fossilization at each period was favourable for their preservation, and what has been the degree of care or thoroughness of search in collecting the fossils. By neglecting such considerations, and considering the numbers in lists as too positive in their nature, students are apt to be misled as to what was the actual condition and development of the organic world.

The *Foraminifera*, of which twenty-two species are mentioned by Mr. Prestwich as from zone 3, and forty-two are enumerated by Professor Jones from the London clay generally, are best represented at the present day in waters of moderate depth and in warm regions. Judging from the figures this group was comparatively poor, since more than sixty species occur now on the British shores, and in the richest localities, such as the Mediterranean, they amount to nearly 300. Looked at as a whole they seem to indicate that the bottom on which they lived was covered by not much over 100 fathoms of water. *Globigerina* might indicate deeper seas, but the same species as is found in the London clay may be picked up by hundreds in a shelly marl on the shores of Connemara. The list is especially noticeable for the absence of the Nummuline group, which forms so conspicuous a feature in the Bracklesham and other middle eocene beds ; as also for its considerable similarity to the list of liassic forms as determined by Professor Jones. There are thirty-three liassic species in the west of England belonging to ten generic or sub-generic groups. Of the groups six, or more than half, occur in the London clay ; and of the species nine, or nearly one-fourth, are met with in the tertiary beds ; while on the other hand Mr. Prestwich remarks that it is doubtful if there is one species common to the London clay and the Bracklesham sands. There seems to be an anomaly here. Either Mr. Moore is wrong in assigning the species to a liassic age, or Professor Jones is wrong in his determinations, or it is not safe to conclude how near or how far strata are chronologically related from the amount of resemblance or dissimilarity presented by their fossil foraminiferal contents.

The *Actinozoa* are very poorly represented, but it is probable the fossils formed a tithe only of the fauna living during the London clay period. The *Graphularia* was probably a mud dweller, and as will be seen it occurs in all the zones in which *Actinozoa* are found. *Mopsea* usually dwells on rocks and stones, and was probably drifted on to the London clay bottom. Most of the corals were also fixed to rocks and stones when alive. They belong chiefly to the family *Turbinolidæ,* which is the most abundant of the corals on the British shores. But this family is far less numerous in the living fauna than the soft bodied *Actinidæ,* and it may be presumed that sea anemones were also abundant in the London clay period. The list, short as it is, is remarkable for the number of extinct and foreign genera in it, and for only one genus being represented by more than a single species. *Stephanophyllia* is not British now, but is met with in the West Indies. *Balanophyllia* is a nearly allied genus, and is now found on British shores. *Paracyathus* is the only genus still remaining in the British fauna, in which it is represented by three species.

The six species of *Echinodermata* in the third zone are different from any that occur in zone 2, and only one is known in zone 1. Few of the forms ascend to higher levels, and nearly all the genera have either migrated to other seas or become extinct. The species in the third zone belong to genera which flourished in the secondary period, but which appear to be near the end of their existence at this period. *Bourgueticrinus* is nearly allied to the oolitic *Apiocrinus,* with which indeed it was associated; while its last representative is not known to be more recent than the early tertiary period. At the present time the family *Apiocrinidæ* is represented only by the *Rhizocrinus loffotensis,* which is generally distributed in the deeper parts of the North Atlantic, and which appears to be a form for which the present condition of things is unfavourable. It is generally the case with the last genera and species of a group, and with species which are not under the most favourable conditions for existence that they undergo great variation. *Bourgueticrinus* presents this condition during the later chalk and earlier tertiary periods; but *Rhizocrinus,* the living representative of its family, "looks like a *Bourgueticrinus,* which has been going to the bad for a number of ages; which was somehow getting worsted in the struggle for life." (Professor Wyville Thomson). Of the genera in zone 2, *Cœlopleurus* and *Hemiaster* are now extinct; *Goniaster,* which occurs in zone 1, is another genus which commenced and flourished in the secondary, and which lingered on into the tertiary era, and died out before it had terminated. Of all the echinoderms *Astropecten* is the only genus which flourishes in modern seas; like many of those already mentioned it has been traced back as far as the oolitic period, but not further. Taken as a whole this small group has a closer relationship with secondary faunas than with those living in modern seas. The nearest living analogues exist in the deeper parts of the North Atlantic. The species have not been met with in the Bracklesham sands; indeed, it is doubtful if they ascend higher.

Of the annelids there is little to be said. *Serpula,* according to the determinations of palæontologists, is ubiquitous, and, like *Vermicularia,* is attached to shells or rocks. *Ditrupa* usually lives free in mud, and the recent living specimens have been found in water from 70 to 140 fathoms deep in various parts of the North Atlantic. The *Crustacea* form a remarkable assemblage, most of the species being peculiar to the London clay. Many of the genera of *Entomostraca* also occur in the lias, but no species is common to the two formations. This is noticeable since the liassic species are associated in the same deposit as the *Foraminifera,* of which, as we have said, several species are common to the lias and the London clay.

The lamellibranchiate molluscs maintain a nearly uniform development, specifically. The oyster family occurs in all the zones, but there is very little community of species, *Anomia lineata* being the only form which is recorded in more than one. In the basement bed *Ostrea* only is represented; in zone 4 it acquires a greater development, *Ostrea* being more numerous in species and in individuals, and is associated with *Anomia.* In zone 3 *Ostrea* falls off, while a third genus, *Pecten,* is represented. In zone 2 *Ostrea* is absent, or rare, and *Pecten* is more abundant individually; and in zone 1 *Ostrea* alone occurs. All these genera extend far back into secondary times, and exist in great profusion in our present seas, being widely distributed in space and depth. The *Aviculidæ,* or wing-shells, are represented by *Pinna* and *Avicula,* which occur generally at all horizons; although they appear to be absent from the basement bed. The species also range from the lowest to the highest zone. The *Mytilidæ,* or mussels, are represented sparingly by *Lithodomus* in the basement bed, and more abundantly by *Modiola* at all levels, the greatest development of which is in zone 2. The *Arcadæ* are numerous. *Nucula* occurs in the basement bed, and is represented by four species in zone 3, of which two re-occur in zone 1, and a third in zone 2, where it is associated with a species not recorded from the other zones. *Pectunculus* occurt at all levels, except zone 3. The two species in the basement bed do not ascend higher; but *P. decussatus,* which is found in zone 4, is met with as high as zone 1. The *Trigoniadæ, Unionidæ, Chamidæ, Hippuritidæ,* and *Tridacnidæ,* are not represented. *Cardium* represents the *Cardiadæ:* there are three species in the basement bed, of which two ascend upwards. *C. plumsteadiense* becomes most common in zone 3, and *C. nitens* in zone 1. The *Lucinidæ* do not occur in the basement bed nor in zone 4, but two species of the small sub-genus *Cryptodon* are found in zone 3, of which one species ascends into the higher zones. The *Cycladidæ,* which frequent rivers and brackish waters, are represented by *Cyrena cuneiformis* in the basement bed. The *Cyprinidæ* are most abundant in zones 4 and 3; in the latter there are three species belonging to the genera *Astarte, Cyprina,* and *Isocardia.* The *Veneridæ* are represented by the single genus *Cytherea,* of which three species occur in the basement bed, two in zone 4, and one in zone 2; being absent from the other zones. *C. obliqua* is found in all the zones which yield the genus. There seem to be no species of *Mactridæ,* although it hardly seems probable that they did not occur in the British seas of the London clay period. *Tellina* is present in the basement bed, *Sanguinolaria* in zone 2, and *Syndosmya* in zones 3, 2, and 1; so that the family *Tellinidæ* is mainly represented by the last-mentioned genus, the living species of which are mostly boreal. The *Solenidæ* also are sparingly developed. The *Myacidæ* are more abundant. *Glycimeris* probably occurs in the basement bed; *Corbula* is associated with it, and is represented by *C. globosa* in zone 2, a species which becomes more abundant in zone 3. *Panopæa* occurs in zone 4, and again in zone 2. *Neæra inflata* is met with in the three uppermost zones, but is most abundant in the highest. *Glycimeris* is one of the few genera which have not a long pedigree, and widespread distribution; and hence it is a safer guide to the climate and oceanic conditions of the period than those genera which thrive under many varied circumstances. As a fossil the genus has not been found out of Europe, while the living species are restricted to the colder parts of the North Atlantic. The *Anatinidæ* are represented by *Pholadomya, Thracia,* and *Anatina.* The first-mentioned genus embraces four London clay species, all of which occur in zone 3, and one of them ascends into zone 2. It was particularly abundant in secondary strata, but only one species exists, and that one is confined to the coasts of tropical Africa. No species of *Gastrochænidæ* are mentioned in the lists. The *Pholadidæ* are represented by a *Teredo* in zones 4, 3, and 2; by a *Teredina* in zones 4 and 2; and by a *Pholas* in zone 4. The lamellibranchiates agree with most of the classes already mentioned in that the prevalent genera are such as have lived on from oolitic times, and also in having a strong affinity with the fauna now living in latitudes north of Great Britain. They differ in belonging to genera which still flourish in modern seas. To us it seems that although these genera are now scattered nearly all over the world, the relationship of the London clay species is nearer with those which occur to the north, than with those which occur to the south of the latitude of London. Sir Charles Lyell considers that the marine fauna indicates a warmer climate than the present, mainly because some of the genera, such as *Voluta, Nautilus,* and a few more are now to be found only in more southern and warmer seas. The great mass of the evidence would imply a moderate rather than a tropical climate, if the present distribution of the genera of the London clay period be regarded as the criterion. We imagine, however, that it is not safe to infer the nature of the climate solely from the distribution of marine faunas. The migration of genera, the extension and contraction of their areas of distribution, and their relative numerical development, seem rather to be regulated by the facilities afforded for moving from place to place, such as the distribution of sea, and many other conditions, of which climate is not the most important. It is, however, remarkable that the terrestrial fauna and flora are most decidedly indicative of a warm climate; but we cannot go into details, but will quote a passage from Mr. Prestwich which explains how it happened that the terrestrial organisms of the London clay period, luxuriating in an almost tropical climate, have been buried in the same sediments as have entombed a marine fauna which seems to have been fitted for a cold area. "I have before shown the probability of the existence of dry land to the south and an open sea to the north during the Thanet sands period, and of more insular conditions during the Woolwich and Reading series period; and now with respect to the London clay the evidence tends in the same direction. With one exception, which proved unimportant, I have never found any transported rock fragment in the London clay that would enable me to infer the direction of the land and its main rivers during that period. If, however, we take the evidence afforded by the organic remains, we shall obtain some peculiar results. If, for example, we look to the molluscs and plants, we at once perceive a want of accordance between them; we find in the former an absence of that group of markedly tropical forms which seem to have flourished in the later sea of the Bracklesham period. The prevailing genera are, on the contrary, such as could live in colder regions. Taken altogether, it indicates a moderate rather than a tropical climate, and yet the fauna is, as far as we can judge, certainly tropical in its affinities. It is interesting to observe at this early tertiary period the same evidence of those climatal conditions dependent upon latitude which become more strongly marked as we approach our own period; for those differences in the fauna and flora arise, I believe, from the circumstance that the London clay was deposited in a sea open to the north, and therefore with an in-set of cold currents determining the existence of a group of molluscs, such as we might expect to find inhabiting waters of moderate temperature; whilst, judging from the quantity and extent of the detritus, there probably existed to the south an extensive continental area, through which flowed a large river which brought down the sediment forming the London clay, and all the marvellous remains of plants and of land and fresh water remains entombed in it—remains which seem to be a vegetation of hot or even tropical climates, and to a land fauna in keeping with such a temperature. If this were the case we should have during the London clay period a continental area stretching southward of England and the north of France, and a sea spreading to the northward of this land; while the subsequent accumulation of the Bracklesham sands took place after the submergence of that land and the immigration of a marine fauna from more southern seas, into which some few only of the forms of the older sea were continued—geographical conditions which I hope, in a subsequent paper, to show to be in perfect accordance with the limited range southward of the London clay and the correlation of the Bracklesham sands with the widespread deposits of the *Calcaire grossier*, and other associated beds of the Paris tertiaries . . . . In some respects the London tertiaries, taken as a whole, are, however, even less tertiary (meaning by that that they present, in many of the generic forms, a closer approach to those now existing in our climate) than the Bracklesham sands; for, with a greater per centage of older forms, they nevertheless contain a large, and probably a larger, proportion of forms such as now flourish on the land and in the sea in these latitudes. The greater number of the common fishes frequenting our seas have their types at this early tertiary period—the Reading plants are such as our existing woods might furnish the analogues of,—and the molluscs, the lamellibranchiates especially, have many representative forms in our present seas. In considering all these singular vicissitudes, and in contemplating the extent to which certain more northern influences operated in giving a large portion of the fauna of the London tertiaries an aspect much more closely resembling that of the present day than is found to exist in many more recent deposits, the question suggests itself—of how far that law, enumerated by Professor E. Forbes, and according to which the distribution of molluscs in depths of southern seas is equivalent to their appearance at lesser depths, or at the surface or parallels of latitude of more northern seas, may by analogy be applied geologically in accounting for any abnormal condition in the vertical succession of organic remains such as here occurs? Can it be that such a group of generic forms, allied to and closely resembling those found in the same zoological province at the present day, had a yet older existence in more northern provinces;—that generic forms of temperate regions have travelled from the north, and have been gradually spread further south, giving, when they encroached upon the more southern forms, a more recent aspect to the faunas of such various geological periods than prevailed in those of the same localities when changes in the distribution of land and water brought back for a time the southern forms which had been temporarily displaced?—a view almost unavoidably suggested by the fauna of the London tertiaries as compared with that of the Bracklesham and associated beds, and confirmed by the independent physical evidence which we have of seas open to the north during the former and to the south during the latter period."

(Prestwich, *Q. J. Geol. Soc.* x. p. 403—419; 435—454; xi. p. 206—246; Prestwich, *The Ground beneath us*, 1857; Whitaker, *Memoir of the Geol. Survey of Great Britain on Sheet* 7 *of the Map of the Geol. Survey*, 1864; Sir C. Lyell, *Elements of Geology*, 1865.)

LUDLOW ROCKS [SILURIAN SYSTEM, E. C. S.]

M

MACROCHEILUS [E. C. vol. iii. col. 573]. A genus established by Phillips in 1841, which is usually placed in the family *Pyramidellidæ*, belonging to the proso-branchiate order of the class *Gasteropoda*. This arrangement can be regarded only as provisional, for in few classes is there so much uncertainty respecting the true characters and correct definitions as amongst those of univalved mollusca. In Woodward's 'Manual of the Mollusca,' the genus is placed at the end of the family, and after *Loxonema*, as though its precise affinities to the genera which are represented by living species had not been satisfactorily determined by the author. In Chenu's 'Manuel de Conchyliologie,' which mainly follows the arrangement of Messrs. Adams, it is placed after *Chemnitzia*, and before *Odostomia*; but there does not seem any special reason why it should occupy this position. The true position of the genus in a natural classification is quite unsettled, and it may even be doubted if *Macrocheilus* should be associated with the slender, tapering, many-whorled shells of *Eulima*, *Chemnitzia*, and *Pyramidella*, &c. Granting that it belongs to the *Pyramidellidæ*, its species will then be amongst the oldest known representatives of that family, of which this genus, together with *Loxonema* and *Chemnitzia*, occur as low down as the Lower Silurian strata. *Loxonema* is restricted to the palæozoic series; and perhaps *Macrocheilus* is, for all the fossil species occur in those strata only. Some years since, however, Mr. A. Adams dredged from a depth of 63 fathoms in the Korea Straits of the Sea of Japan a species which he named *Macrocheilus japonicus*. *Chemnitzia* is also known as far back as the lower Silurian period, and, like *Macrocheilus*, is still represented in the Japanese seas; but its present distribution is wider, as it ranges nearly all over the world, and its past distribution has been more continuously traced, since some species are found in every group of rocks.

We have little faith in the specific determinations; but at least twenty species have been described. Murchison in his 'Siluria' mentions one Caradoc species, *M. elongatus*, which again occurs in the Ludlow rocks; and he notices a second species, *M. fusiformis*, from the upper Llandovery group. During the Devonian period the genus still resided on the British area, and even *M. elongatus* had neither died out nor migrated elsewhere. So far as the fossil remains indicate it had become more abundant; for there are not fewer than six species in the Torquay beds of South Devon. Of these only three species are known elsewhere; one, *M. brevis*, is the only species discovered in the middle Devonian of North Devon; a second, *M. harpula*, is found in the middle Devonian of Belgium; and a third, *M. imbricatus*, although not recorded from any other part of the Devonian series, either in England or abroad, is met with in the lower carboniferous of west Scotland. It is in the last-mentioned group of strata that the genus seems to have acquired considerable development, upwards of ten species occurring in them in various parts of the British Isles, but most of them in the carboniferous limestone of the more central parts of England. In Dupont's account of the lower carboniferous strata of Belgium he mentions but two species, one of which, *M. acutus*, also occurs in England and Scotland. Koninck describes two species from rocks of this age in the Punjaub Salt Range, both of them unknown, as yet, anywhere else. The species, so far as the evidence goes, did not extend over very wide areas, and appear to indicate different zoological provinces. The genus becomes less abundant in the coal measures of Europe, a few specimens only having been found; but numerous species have been obtained from the coal measures or upper carboniferous series of Missouri, Kansas, Iowa, and a few others of the United States, some of which closely resemble European species of the lower carboniferous period. Thus, *M. kansasensis* is very similar to *M. acutus; M. ponderosus* of Kansas territory, and *M. texanus* of Texas, remind one of *M. imbricatus*. The American species seem to have had restricted ranges, for those of Missouri and Texas are mostly different from, though in many cases nearly allied to, the Iowan species. The coal measures of the last-mentioned state have yielded four species, and a fifth has been described from the neighbouring state of Illinois. One of these is described by Hall as a new species under the name of *M. fusiformis*. This is distinct from the Silurian species, which had previously received the same name, but curiously enough there is rather a close similarity between the two. The genus is poorly represented in the Permian strata. After this nothing more is known of the genus prior to the recent *M. japonicus*. If this last really belong to the same genus as the palæozoic species, it may be expected that *Macrocheilus* will be found in the secondary and tertiary rocks.

MAN [E. C. vol. iii. cols. 656—677]. The knowledge of man has of late years been pursued by such a vast accession of students that the science will probably attain in a few generations to dimensions such as are hardly conceivable now. At present, however, statements are rapidly accumulating, and the foremost immediate requisite is the sifting of truth from error and prejudice, the accurate definition of terms, and the establishment of principles. The stability of the science mainly depends upon the progress made in these various points. In the E. C. no special name is given to this science, but anthropology is applied to that branch of it which concerns the zoological relations of man and the lower animals; and ethnology to that which deals with the relations of groups or races of men amongst themselves. Amongst the early students of man anthropology was considered to mean the whole science, and not a portion of it, although their views as to its scope were not very extensive. Most authors now use the word in its original widely extended sense. Broca defines anthropology as that science which has for its object the study of the human group considered in its *ensemble*, in its details, and in its relations to the rest of nature; and thus outlines the scope of the science in an article on "Anthropology," in the 'Nouveau Dictionnaire Encyclopédique des Sciences Médicales,' the English version being that given in the 'Anthropological Review,' vol. v. p. 195:—"To say that anthropology is the natural history of mankind might in most minds give rise to the idea that it is a purely descriptive science; that it confines itself to distinguishing and classifying the various races according to the physical type; but this interpretation must be carefully guarded against, and the more so, since there has been a time when anthropology, still in its infancy, was confined within such narrow limits. The definition we have thought proper to adopt is more significative, and it has, moreover, the advantage of indicating with sufficient precision the three great series of facts, the reunion of which constitutes anthropology. We may, in fact, bring all the studies relating to the human group under three heads. (1) It is necessary to determine the position of this group in the series of creatures—a question apparently very simple, since the supremacy of man over all animals is incontestable. It is, nevertheless, very difficult to be an impartial judge in our own case, and the study of this question proves it. Pride, one of the most characteristic features of our nature, dominates in many minds over the calm testimony of reason. Like the Roman emperors who, intoxicated by power, finished by looking upon themselves as demigods, so the king of our planet imagines that the vile animals subject to his caprice has nothing in common with his own nature. The vicinity of the ape inconveniences and humiliates him; he is not satisfied with being the king of animals, but desires to establish that an unfathomable chasm separates him from his subjects, and, turning his back upon the earth, he takes refuge with his threatened majesty in the nebulous sphere of *the human kingdom*. But anatomy, not unlike the slave who followed the car of the victor, exclaiming, 'Memento te hominem esse,'—anatomy disturbs him in this self-admiration and reminds him of the visible and tangible reality which allies him to animality. The doctrine of the human kingdom is thus placed side by side with another not less radical doctrine which pretends to derive man from the ape; and between these two extreme opinions others arise, which, according to a more or less rigorous interpretation of anatomical characters, present the human group as constituting now a species, now a genus or a class, or a branching off of the zoological series. A critical examination of the contradictory arguments adduced in favour of these different appreciations leads to studying, on one hand, the characters common to man and the animals nearest to him, and on the other, to finding out such characters as are peculiar to man. It becomes, moreover, necessary to see to what extent these analogies and differences agree with the laws presiding over the serial distribution of the groups called genera, species, families, &c., to investigate whether the gradation which obtains in a lower scale is preserved in a superior scale; to mark the distance existing between the highest term of the simian and lowest term of the human series, and to examine the arguments of those who do not consider that distance impassable. That portion of anthropology which comprises the study of these zoological questions is entitled to the name of *Zoological Anthropology*, and may be defined as *the study of the human group considered in its relations to the rest of organised nature*. (2) The human group once characterized, circumscribed, and classed as a group in its *ensemble*, must then be considered by itself; it must be divided and subdivided, and each of these separate groups must be studied separately. This constitutes *Descriptive Anthropology*. Numerous physiological differences coincide with the physical differences. The muscular force, general sensibility, the degree of the perfection of the senses, especially of sight, hearing, and smelling, the mode of articulating certain sounds, the odour of the perspiration, the power of resisting heat or cold, the pathological aptitudes and immunities, the period of puberty, the duration of female fecundity, &c., all present in various peoples more or less extensive variation. Finally, that which varies most is the degree of activity of the intellectual functions, the predominance of such or such a group of faculties, the development of the social condition and perfectibility, that is to say, the aptitude to originate or to receive progress. Thus, whether we consider humanity as regards the external conformation, or the anatomical, physiological, intellectual, moral, and social characters, we find considerable differences among the groups composing it. But although the modifications of the different orders of characters do not always present themselves abreast, there are some which present a sort of solidarity. Thus the obliquity and the projection of the face, constituting what is called *prognathism*, more or less black tint of the colour of the skin, woolly hair, and intellectual and social inferiority are frequently associated; whilst a whitish skin, smooth hair, an orthognathous face are usually the appanage of the more elevated peoples of the human series. Consequently, although the serial distribution obtains here as in other zoological groups with its infinite gradations and degradations, its unions and anastomoses, it is possible and even easy to distinguish between the innumerable variations of the human type a certain number of secondary types, around which all these varieties group themselves with more or less precision. As regards these varieties, they have received the name of *races*, which engenders the idea of more or less filiation between individuals of the same variety, but which neither affirms nor denies the question of parentage between individuals of different varieties. The name *species* implies the solution of the question as regards the diversity of origin; the term *varieties*, taken in the special sense attached to it in natural history, would, on the contrary, imply that the whole human group forms but one species. From this results the inconvenience of speaking two different languages, according as one is monogamist or polygamist, and the non-acceptability of these terms to those who look upon the problem of origin as doubtful. The word *races*, on the contrary, may be adopted by all, and it is for this reason that it is now prevalent. (3) The third branch of anthropology, last in the logical order of regular scientific evolution, but the first in importance, is *General Anthropology*, which has for its object *the study of the human group in its ensemble*. Here it is especially important to establish a line of demarcation between anthropology and other sciences which treat of man. All, without exception, furnish to general anthropology numerous facts, without which it could not exist. They make known to us the individual man, and it is clear that a collection of individuals cannot be studied in its *ensemble* if we did not commence with the study of the individual type, which forms the unit of the number. But anthropology only borrows from the other sciences that which concerns man, considered as forming part of a group. Some examples are necessary clearly to explain this distinction. The study of the cerebral functions forms part of physiology. Those, for instance, who search for a certain relation between the volume of the brain and intellectual power study a question which thus put is purely physiological. But if, instead of confining the comparison to individuals resembling each other by their physical characters, and differing in intelligence, we compare a series of individuals of a certain race with a series of individuals belonging to different races, we quit the territory of pure physiology and enter the domain of general anthropology, just as in treating of a subject of zoological anthropology we study the same question with the object of establishing a parallel between man and the rest of animals. The description of the skeleton, the muscles, nerves, viscera, skin, &c., belong to anatomy only; that of individual varieties equally so. But whenever an organ, either in form, structure, or volume, presents differences in various races, the history of these variations belongs to the comparative anatomy of races, which is frequently put under contribution by ethnology, but which, studied in its *ensemble*, belongs to general anthropology. The study of cancer, tubercular affections, dysentery, yellow fever, &c., form parts of pathology; but when the pathologist states that either of these diseases presents, according to race, differences in frequency, gravity, and progress, and these differences cannot be explained from external conditions, but must be referred to the organisation of the respective races, he contributes to the progress of the comparative pathology of races which forms part of general anthropology. Hygiene, which has for its object the preservation of health, is not a branch of anthropology. Even public hygiene, although it embraces questions relating to the health of a whole people, or of a great number of peoples, is perfectly distinct from anthropology. But the hygienist, by studying the conditions favourable or noxious to the health of individuals or masses, is obliged to inquire, how far the influence of media is capable of modifying the organisation; how far these modifications of the individual by external conditions may be capable of transmission from generation to generation, and these two questions form an integral part of the problem of races, one of the most important of general anthropology. The psychologist, who studies in himself or in other individuals, the faculties of the mind, the feelings, or passions, is not an anthropologist; but who, extending the field of psychology, observes the differences existing between peoples and races in reference to intellectual power, perfectibility, sociability, artistic, scientific, literary, industrial, religious, and political aptitudes, he participates in the work of anthropologists; and it is thus the comparative psychology of races becomes one of the most interesting branches of general anthropology. It is unnecessary to multiply examples to show how general anthropology puts under contribution all sciences which have man for their object, without being confounded with these sciences. Anthropology even borrows from sciences altogether foreign to the study of the individual man, but which still furnish facts concerning men as members of a zoological group. Climatology indicates the condition of the various media in which man can exist; zoological and botanical geography make known to us the existence and the distribution of distinct fauna and floras, of multiple centres from which the actual centres spring, contrary to a general prejudice which derives, if not all plants, at least all animals from one focus; and it is at once perceived how important the knowledge of this fact is for him who inquires whether the human genus had only one or several cradles. Geology in its turn describes the gradual changes which have so many times modified the condition of life on the globe, and makes us appreciate the immense time which must have elapsed between their different epochs, and the great antiquity of the quaternary strata which contains the remains of man or of his handiwork; and palæontology, finally, placing man by the side of species he has survived, reveals to us the conditions of the existence of man in those primitive times, the record of which is lost."

The true scope of the science of man has been so misunderstood by many authors, that we have thought it better to give the views of one of the most successful students of that science rather than any remarks of our own. So vast is the field that the writer cannot attempt, at present, to traverse the whole of it, although a strictly supplementary article would require the adoption of such a course; and consequently we must content ourselves with a few observations on one or two of the principal anthropological problems, namely, are men derived from a single or many original pairs or protoplasms? and at what period did man first appear?

The first question is of a multiple character, and suggests several trains of inquiry. It may be supposed that originally there was a single individual; or that there was a single pair, sexually different, but, with this exception, physically identical; or that there was a single pair, both sexually and physically different; or that there were several individuals, or several pairs, which were either similar or dissimilar. There is no direct evidence on any of these points, so that we are reduced to the consideration of circumstantialities. Man is like the domestic animal in that he is withdrawn more or less from the direct influence of natural media, and like them he is remarkably susceptible of variation. Generally speaking the individuals of an animal species have a considerable uniformity of character, which circumstance seems to be due to the conditions favourable for the existence of all being uniform. The varieties of man, whether we consider him to be a species, or a genus, or even an order, are more numerous than in other zoological groups having corresponding values; and the range of variation, by which we mean the area of characters over which variation may occur, is greater than in all the rest of the animal kingdom. Thus man may present differences as respects the osseous, nervous, muscular, and other organic systems, in the same way as other animals; like them he may present dissimilarities in his outward features, such as colour of skin, eyes, hair, &c.; the nature, distribution, and relative abundance of hair; general size and relative proportions of parts, and many other matters. In addition to all these, his differences have relation to the kind, intensity and relative proportions of psychical qualities which are absent or rudimentary in animals; to modifications in the development of languages, of sciences, and of arts, points which he alone amongst animals has possession of. The facility with which variation occur differs for each group of qualities, being greatest in those which are special to him, and least in those which he shares with the lower animals. So far we conform to what seems to be a law of nature, that those qualities which are spread over the smallest individual, varietal or specific areas are more easily affected than those which are common to a larger biological group; and, to express the same thing from an hypothetical point of view, that, generally, characters are alterable to a degree inversely corresponding with that of their acquirement. These statements may be regarded as mere assertions by some, since we have not adduced a particle of evidence in support of them: they are founded upon general impressions derived from what are believed to be facts. In physics a phenomenon is the result of a definite concatenation and co-ordination of forces of a particular kind; so long as that particular arrangement is maintained, so long will the phenomenon persist; if any alteration occurs in the forces specially relating to the phenomenon considered by themselves, then a corresponding change will occur in the phenomenon. But it may happen that great changes may take place in the surrounding conditions and yet no change take place in the phenomenon, provided those changes do not affect the special forces alluded to. A dew-drop on a blade of grass owes its rotundity and persistence to a multitude of forces acting in definite directions, such as the adhesion of the water to the leaf, the cohesion of the fluid particles amongst themselves, the action of gravitation upon the drop, the presence of a certain amount of moisture in the atmosphere, the prevalence of a given temperature, and many other circumstances. Great changes may occur in its vicinity without leading to its destruction or dissipation, such as a great battle amongst men, a flood in a contiguous valley, &c.; but if any alteration is superinduced in the group of forces which tend to make the drop what it is, it disappears. Such changes may be very slight, and yet be effective, provided they are applied in the proper direction. Thus it may be that a break may occur in the clouds allowing the sunshine to play upon the drop for a few minutes, and it gradually disappears by evaporation; or an insect may shake the grass sufficiently to dislodge the drop. So we believe it is with man. He is the outcome of a special and definite arrangement of force and matter; and any modification or change which occurs either in those forces or in the associated matter is attended by a change in the man, and the change is proportioned to the effective application of the force. In the case of a dew-drop we can follow out the relation and sequence of events and give an explanation stating to what laws these events are due; but in man the conditions are so complicated that there is the greatest difficulty in tracing the origin of the changes which we do see, and of those which we may infer have taken place. Man does vary, a statement in which all agree; the matters of difference relate to the causes or conditions of those variations, and the extent to which they may accumulate. Some say they are so great that man cannot be referred to one origin, but the number of original protoplasms, that is, men, or organisms, from which he has been derived has been variously estimated at from two to hundreds. The advocates for the plurality of mankind bring forward the colour of the skin as one of the indications of the soundness of their doctrine. How can it be maintained that the jet black negro, olive-coloured Abyssinian, the red American Indian, and the light-coloured European, have descended from the same stock? The tints, they say, have been retained for generation after generation without appreciable alteration, and in some instances are known to have remained unaltered for as far back as history can carry us. Moreover, it is pointed out, that if the negro is transferred to America he remains black, and shows no tendency to become coppery red, and so with the other examples cited. It is further noticed that the distribution of colour has no apparent connection with the distribution of land or of climate. On the other hand, objections may be made to the truth of all these positions, either on the ground that the facts are selected, or the premises have not been established, or that the phenomena are otherwise explainable. The colour of the skin is one of the most variable characters in man; in every nation there are differences, and conformity never occurs throughout the population of a large town, or a large country; and changes occur in the same individual according to his habits. A student who has long been resident indoors acquires a lightness of tint, independent of the pallor of ill health; but if he indulges in a few weeks of constant out-of-doors exercise he becomes perceptibly browned. The darkening of the complexion does not appear to depend solely upon the heat of the sun's rays, as its depth has no direct relation to the degree of temperature. There are other causes in operation. In conformity with this it is noticeable that the wealthier classes in most civilized countries are as a rule fairer than the classes which constantly work in the open air. Hence it will be gathered that the depth of tint may vary in the same climate, provided the individuals living under that climate are exposed to it in different degrees. We have used the word climate for convenience, and mainly because it has not been ascertained what action the elements of climate have upon the skin. And if each element be taken in succession, no harmony is to be found in its distribution and that of the colours of people. Thus as regards temperature no black men occur in the American tropics, although parts of it are as hot as places where black men dwell. The New Zealanders and Sandwich Islanders are remarkably dark as compared with Polynesians generally, although they reside in the mildest climates. The natives of equatorial America are lighter than the Indians of more northern regions. The Lapps and Finns are darker than the Malays. Instances of this kind might be enumerated almost by hundreds. The facts prove that the present distribution of climate does not tally with the distribution of colour; nevertheless, they do not prove that climate has so little effect as not to be an important element in the production of colour. People have not always dwelt where we now find them; migrations have constantly been going on, and tribes and nations have been constantly intermixing. Hence, supposing that climate did regulate colour, we should expect to find apparent anomalies of this kind. What one requires to know is the history of the migrations of each people, and the duration of their stay at each place. Where the same people live in a country partly mountainous and partly low ground, it usually happens that the darker complexions are found in the hotter and lower districts. On the Zambesi, for instance, the natives are very dark on the lower portion, while the inhabitants of the more mountainous interior are the colour of milky coffee. If a tribe of black people were to occur in an alpine region we might safely infer that they had recently migrated there. On the same grounds it is probably true that where a race has a colour markedly different from that which prevails in a given latitude, it has been recently established in that latitude. If it is unusually dark, it has probably come from a warmer region, as in the case of the New Zealanders, who, judging from their traditions, have not been many centuries in New Zealand, and who came from some more northern island. It is very probable that Waitz's view is correct, namely, "that the colour of the skin, though not always in proportion to the latitude and mean temperature, is essentially influenced by climate; that the extent and mode of this influence is chiefly regulated by habits and mode of life; that next to these, descent has the greatest influence; and that food also has its share in the production of colour, though in a subordinate degree. It is further shown that hot and damp countries, unprotected by forests, and a mode of life which expose the organism to climatic influences, strongly favour the darkening of the skin. Frequent and great alterations of temperature, especially sudden changes from wet to dry, brown the skin in every climate and in every race, if the body is much exposed and unprotected." In dealing with this question it is highly desirable that all these elements should be estimated as regards their quality, their intensity, and their duration; in the same way as the kind, amount, and direction of forces are studied which combine to form a dew-drop. It is manifest that men do differ, and every race of men may vary; but are the differences such that no observed range of variation could cause the evolution of a negro on the one hand and a white European on the other from a single pair of intermediate tint? The Jews who are generally so particular in marrying amongst themselves, who are a people the characters of which are well known, whose history is traceable, and who have settled amidst a greater number of other tribes than probably any other nation; the Jews, we repeat, are remarkably heterogeneous in their colour. Amongst Europeans they are brown or fair in complexion; but amongst the Hindoos they are as black as the natives around them. In this case the transformation has required centuries to be effected. The Europeo-American has been a few centuries in America, but has diverged from the European types, and approached somewhat to that of the natives. Here the change has been apparently slow, owing to constant accession of fresh blood from the mother country. As with the colour of the skin so it is with the characters; and so far as we can judge there is nothing to prove positively the plurality of mankind, and there is nothing which decidedly disproves that man has not originated from a single pair. Nay, more, we consider it to be quite consistent with truth that man has originated from one stock; but on this last supposition the date when that first stock lived must be removed to a very remote period; and this mainly because changes in faunas and in man are very slow in their operation; and because the earliest men we are cognisant of presented considerable differences amongst themselves. The slow development of civilisation and of languages within historical times renders it almost certain that their development was equally slow in prehistoric times. But languages and civilization are known to have sprung up and vanished prior to natural records. Considerations of this kind impress one with the belief that man is of great antiquity. Geological evidence confirms this view.

The existence of man, more especially in Western Europe, has been traced far beyond the reach of history or tradition; and it is difficult to decide where to draw the limits between the palæontological and historical aspects of the subject. We find the implements which he made in stone and bone indicative of an industrious hunting and fishing population, associated with animals which have long ceased to exist. In carefully considering the circumstances under which they occur, there may be detected a gradual progress of improvement, in the case of the former dwellers in Western Europe, from the makers of old flint implements of a few types of form, and unpolished, to those who fabricated instruments for a greater variety of purposes, and expended more labour and design in polishing and ornamenting them. From these we pass by gradual stages to the nations who employed metal, and started the beginnings of many of those arts and sciences which have now grown into their present vast proportions. It is the proper domain of the historians of those arts and sciences to trace the development of each, so that in the present place we shall only allude to them as signs of the sequence of peoples and of the rate of movement of human events.

The geologist has shown that Western Europe has been exposed to a cold period, during which all the high lands were covered with ice and snow; that the climate gradually lost its rigour and became like what it now is; and that while these events were happening the land underwent a series of oscillations, whereby it was at one time partially submerged beneath the ocean, and at another raised out of it. These oscillations apparently recurred in a definite order, and may have been more or less contemporaneous over large areas. Whatever conclusions may be arrived at respecting the contemporaneity or non-contemporaneity of any given depression or elevation in two distinct localities of Europe, the depressions and elevations of any one locality may be safely employed as chronometers, or rather chronoscopes. In Great Britain, for example, the land was high during the first part of the glacial epoch; it then sank in most places to the extent of hundreds of feet; a second rise took place, a second depression followed, and this was in its turn succeeded by a third elevation. It was during the second elevation and the subsequent depression that were formed most of the valley gravels in which the flint implements have been found so abundantly. So far as we are aware, no evidence has been recorded that man existed prior to the second elevation, although it is possible that some of the articles bearing man's handiwork, which have been found in caves, may be of anterior date. If we are to believe the statements and inferences drawn from the researches of the Messrs. Bourgeois, Delaunay, and Issel, and of the Marquis de Vibraye, traces of man's existence have been found in the upper pliocene of St. Prest, the pliocene at Colle del Vento, the upper miocene at Pouance, and the middle miocene at Selles sur Cher.

The age of the earliest traces of man in Europe is intimately connected with the age of the oldest valley gravels; and the age of these may be estimated in various ways, according to the rate at which sediments accumulate, the land rises and falls, the faunas and floras are modified, and the arts are developed. But in none of these cases is our knowledge sufficiently copious and precise to warrant anything more than almost random guesses. For example, let us select the gravels of the Somme valley, which have been examined by almost all the eminent geologists, and which are generally referred to as proofs of the great antiquity of man. This valley is excavated in chalk, and is bounded by escarpments varying from 200 to 300 feet in height. Beyond the escarpments is an extensive, slightly undulating plateau, covered by a wide-spread layer of loam devoid of organic remains. Here and there are patches of gravels and sands, the relics of a tertiary formation, which once overlaid the plateau, and whose denudation has been the source of most of the deposits in the valleys and deltas. The valley is in places more than a mile in width, and the gravels, sands, and clays, cover its bottom, and extend to considerable heights up the flanks of the bounding slopes, while peat overlies the deposits in the lower parts of the present valley bottom. In most cases the gravel rests immediately upon the chalk, and is succeeded by the sands, loams, and clays. In the gravel between Amiens and Abbeville, hundreds of flint implements have been obtained, the prevailing shapes being a long flattened oval tapering to a point at one end, a short oval, and long flakes, flattish on one side and ridged on the other. Although neatly formed, their cutting edges have been produced by a dexterous fracture of the flint, and not by grinding. The implements are generally worn either by use or by friction in the bed of the river. They are most abundant in the lowest parts of the gravels, whether situated at the higher or lower levels of the valley. It is also in the lowest parts of the gravels and sands that marine shells have been met with, while the higher strata abound in fresh water species, and have unquestionably been formed by fluviatile action. The marine shells include specimens of *Buccinum undatum, Littorina littorea, Nassa reticulata, Purpura lapillus, Tellina solidula, Cardium edule,* and others, now living on the shores of France. These are mingled with *Cyrena fluminalis,* and many of the ordinary fresh water and land shells still existing in the surrounding district. With these are also associated the remains of mammalia, which have long ceased to dwell in France, such as *Elephas primigenius, Rhinoceros tichorhinus, Equus fossilis, Bos primigenius, Cervus somonensis, Tarandus priscus, Felis spelæa,* and *Hyæna spelæa.* In the Menchecourt sand-pits, and near the bottom of the section, the bones of the hind part of the tichorhine rhinoceros have been found still retaining their proper relative positions, showing that they were still held together by their ligaments at the time of deposition; and a little way off from this spot a whole skeleton was discovered. The conclusions to be drawn from these phenomena might be strengthened by similar facts from hundreds of other valleys in France, England, and other countries. The more important of those conclusions are that the implements are the work of man; that they were placed in the position in which they are found at the same time as the gravels containing them were placed where they now are; and that they are associated with the remains of extinct mammals. But a further sifting of the evidence is required before accepting the further conclusions which have been adopted by many authors, viz., that the valley was in part excavated after the deposition of the gravels at the higher levels; that all the marine shells, flint implements, and mammalia, were originally deposited in the gravels and sands, and that man lived at the same time as the mammalia. Our ideas of the antiquity of man depends, in great measure, upon the views which are taken upon these points; and it has yet to be decided whether the valley was, or was not, entirely excavated before the accumulation of any of the valley deposits; whether all the mammalia were, or were not, living at the same time as the flint implement makers. These are questions which we cannot pretend to discuss fully, and yet much depends upon the answer that is given to them. Messrs. Prestwich and others, as also Sir Charles Lyell, contend that the gravels, sands, &c., were being accumulated while the excavation of the valley was going on, and consequently they recognise a considerable difference in the age of the high level and low level valley gravels. On the other hand, Mr. Tylor, and other geologists, believe that the valley was first entirely excavated, and the gravels subsequently accumulated. On this latter hypothesis the time which elapsed between the formation of the gravels at the highest and lowest levels was probably far shorter than that required by the former. And it seems to us that the latter hypothesis is most consistent with the facts before us. There is no direct evidence in favour of either view, so that one is thrown upon probability and circumstantial evidence in deciding which is most in accordance with truth. Mr. Prestwich admits that the rivers of France and England in their present condition are quite incapable of excavating the main valley, a position which is evident, seeing that they are deposit-accumulators, and not deposit-destroyers, and that it would require a still more powerful agent to scoop out chalk, than to wash away sands and gravel. He also admits that the valleys were formed by rivers having a more torrential character, and more liable to be swollen by periodical floods, than at present. But he contends that the valley is in part newer than the gravel, on the ground that the high level gravels are far above the reach of any flood of the present rivers that can possibly be conceived. Those who hold the opposite view contend for the possibility and probability that valleys one mile wide and more than one hundred feet deep, were at one time filled with running water, and that it was by these vast rivers that the gravels were deposited. The improbability of the latter view is considerably lessened if we have regard to the time when these valleys were formed. In northern Europe as in Scotland, for instance, many of the valleys were excavated at the same time as the glaciers were disappearing, and it was during this time that the land was undergoing its second rise and fall. Most of the valleys of southern England and France were being formed during the same rise and fall, and were probably commenced even earlier, or during the first depression. If in the north the formation of the valleys were coincident with the gradual disappearance of the glaciers, it is by no means unlikely that the excavation of the southern valleys were dependent upon periodical floodings, caused by the melting of the winter snows.

Much of the recent denudation of Europe may safely be assigned to this period, and there is abundant evidence to show that it was characterised by the accumulation of vast bodies of water, which formed great lakes and inland seas. That the Somme may have at one time entirely filled its valley, is rendered probable by considerations such as these, as well as by the circumstance that numerous large valleys debouch into the present valley, which bear indications of having been once filled with water, but which are now quite dry. Dry valleys are not restricted to the Somme, but are met with in connection with numerous other rivers. The contortion of the gravel and the large blocks of stone found in them are best explained by the action of river ice, which is also in harmony with the idea of the river being swollen with molten snow. In some places we have indications of the rate at which the gravels were accumulated. Thus one case has been recorded of a mass of gravel in sand presenting curious contortions. The circumstances indicate that the mass of gravel, three or four feet thick, was frozen together by ice at the time it was laid on the sand; that before it had melted the sand had covered up the mass, and that when it melted the overlying sand fell into the vacant space thus formed and shared in the contortions of the gravel. From this it is clear that four or five feet of sand was accumulated during the melting of the ice, which we cannot suppose took a very long time. As an illustration of the possibility of the water having been accumulated in the Somme valley to the extent required, Mr. Tylor cites the following. In 1866, twenty inches of rain fell in one day in the flat country near Kurrachee. The Mulleer river flows through this country, and in ordinary seasons has not more than a foot of water in its bed. At a place sixteen miles above Kurrachee the valley is crossed by a railway bridge, the girders of which weighed about eighty tons each, and were nearly sixty feet above the level of the stream. On the occasion of this heavy rainfall the river piled up wood and grass against the bridge and rose sufficiently high to overthrow the girders and to carry one of them two miles down the river, where it was buried in the sand. Illustrations of the enormous extent to which rivers may exceed their ordinary bounds, might be cited by hundreds. Thus one or two may be given from localities nearer home, although they are not the best that could be chosen, since they belong to a country which at the present time differs widely from what the Somme district probably was when its gravels were laid down. The water of Leith in Edinburghshire is an ordinary river, but "there are times when it almost disappears amongst the stones, and there are times when the swollen torrent rushes along with the power of a giant" (Stat. Acc. of Scotland, i., p. 109). In 1803 it was flooded for three days, and acquired such proportions that it injured twelve dam heads, and washed away the bridge at Slateford. The Gore, in the same county, is another example. In 1837 it was swollen to an unusual extent, partly owing to heavy rain and partly to the bursting of a pond. It rushed through the valley with enormous force. This, however, was quite an exception; but it frequently happens that the whole valley is inundated when the snow melts after a long continuance of snow storms.

If, then, it be granted that the Somme valley was excavated, and its gravels accumulated by flooded rivers; and that these events followed upon the passing away of a moderate glacial condition of the land, we should be careful to ascertain that the flint implements, mammalian bones, and marine shells, are not derived fossils. Knowing how largely the beds older than the valleys have been denuded, it seems not unlikely that some of the marine shells belonged to strata deposited during an earlier depression of the country, and that some of the mammalia may also have lived and died before the existence of the valley. The main argument adduced to prove that man co-existed with these mammalia is, that the flint implements are associated with mammalian remains, which were evidently bound by ligaments and clothed with muscles; but this does not necessarily imply their co-existence in the living state, since it is well known that the inhabitants of Siberia are still living in the same country in which the tichorhine rhinoceros yet retains its flesh and woolly hair, although the species has ceased to exist there for many centuries: indeed, there is no tradition that it was ever seen alive. As the climate of France during the formation of the valley gravels appears to have closely resembled that of Siberia at the present time, we should expect to find flint implements associated with the legs and skeletons of rhinoceroses, elephants, and cave-bears. So far, then, as the valley gravels of the Somme valley are concerned, there does not seem to be any safe data whereby to estimate the antiquity of the human race, and the same remark is applicable to most other valley gravels.

It has, moreover, been remarked that if these remains of extinct mammals were derived from earlier deposits, we should expect to find some traces of these strata. This may be admitted, and yet, considering how vast has been the denudation by glacial agencies, we should not be surprised if those traces are exceedingly scanty in regions which have been subjected to that denudation. We do not observe any such remnants in the Somme valley, but one instance may be cited in Scotland. At a quarry near Kilmaurs, in Ayrshire, the boulder clay overlies a series of sands and gravels, in which have been found the remains of *Elephas primigenius* and the reindeer. These beds are pre-glacial, and very few traces of the elephant have as yet been detected anywhere in Scotland, whether in glacial or post-glacial beds. In this instance the boulder clay has protected the underlying deposits from denudation. In England the head-quarters of the *Elephas primigenius* is in the Norfolk forest bed, which belongs to the early part of the post-pliocene period. And doubtless several other examples are to be found, more especially in more southern latitudes, which have not as yet been sufficiently explored.

Let us next consider the facts afforded by the peat of the Somme valley, which is more recent than the gravel. This substance forms the lower part of the valley from far above Amiens to the sea. It attains a thickness of more than thirty feet in some places, and all the shells and bones found in it belong to existing species. The peat in many places occupies the site of former forests, as it covers the trunks of alders, oaks, walnuts, and other trees, whose roots penetrate into the gravel below. Numerous remains of Roman and Celtic art occur in the peat, but the depth at which they are found seems to have depended upon the nature of the object and the consistency of the peat. M. Boucher de Perthes found some flat Roman dishes, whose shape and horizontal position it is thought must have prevented their sinking through the peat. Assuming this, and assuming also that the plates fell on what was then the surface of the peat, the French archæologist employed the facts as data for ascertaining the thickness of peat which had grown within a given number of centuries; and from this he comes to the conclusion that the peat grew at the rate of about one inch per century, and that consequently 36,000 years has elapsed since it first began to grow. We believe the estimates are based on false assumptions, and that the peat required a far less time for its formation. The reasons for this belief are given under BOGS, E. C. S., but here we may state that the articles found in the peat do not indicate a greater antiquity than the second or third century before the Christian era, and that as far as the mere growth of peat is concerned, the whole thickness of thirty feet might have been accumulated in less than a century, although we are by no means prepared to assert what the actual time was. The estimate by Mr. Vivian that the uppermost stalagmite floor of Kent's cavern, which overlies deposits containing the relics of man, implies an antiquity of at least 250,000 years, is open to the same kind of objections as have been raised against the other instances we have discussed. The stalagmite does not increase at all now, since none had been formed in the thirty years dating backwards from 1867. Since the time of the Romans there has been a very slight increase. Mr. Vivian takes the rate of growth since the Roman period as the rate at which the whole of the stalagmite was formed. But we have little doubt that the great bulk of the stalagmite was formed under conditions very different from the present conditions, which would enable the floor to form in a far less number of years than is estimated. If Mr. Vivian's mode of calculation were to be extended to the greatest thickness of stalagmite found, and to the three successive floors which have been traced, the supposed antiquity of the earliest deposit would be enormous.

Implements of flint and stone are found so abundantly in almost every country of the globe, that it would be quite impossible to attempt to give details respecting the varying circumstances under which they are found, and their relative ages. It would, moreover, be quite out of place, since the point we aim at here is not to show what were the state of the arts among the people who made them, but to ascertain whether those people lived a few or many thousand years ago. Beyond the few general remarks already given respecting them, we do not propose to go, although there are many interesting points connected with them; but pass on to a few observations on the human bones found associated with flint implements and extinct mammalia, or under circumstances which seem to denote great antiquity.

The fossil man of Denise has been the subject of much discussion among French anthropologists and geologists, and was at one time supposed to have lived long before the valley gravels of the Somme were formed, and indeed earlier than the period during which glaciers were at their maximum development in Scotland. This man appears to have been enveloped in the volcanic ash which was ejected during the last volcanic eruption in Velay; but there is nothing very definite to show when this event took place. There is a lava flow supposed to be contemporaneous with the volcanic ash enveloping the fossil skeleton, which contain remains of *Hyæna spelæa* and *Hippopotamus major*, and which descends so far down into the valley of the Bonne, a tributary of the Loire, as to imply that the valley system has been very little altered since the outflow of the lava. Indeed, there is nothing to show that this fossil is older than the flint implements of the Somme gravels, and it may be much later. Another example supposed to be of immense antiquity is the pelvic bone found at the base of the cliffs at Natchez, on the Mississippi, along with other bones belonging to the *Mastodon ohioticus*, *Megalonyx*, and other species, some of which are extinct, and some still living. The stratigraphical position of this specimen is unknown, but it is supposed to have come from the same clay which contained the bones of *Mastodon* and *Megalonyx*. Without necessarily assenting to the correctness of this supposition, let it be granted that the bone was found in the old clay, which forms part of an old delta of the Mississippi, and is now raised far above the river, so as to constitute the table-land of Vicksburg. Its antiquity even then would probably not be greater than that of the flint implements of the Somme, as pointed out by Sir C. Lyell in the following passage from his work on the 'Geological Evidences of the Antiquity of Man:'—"If, however, I am asked whether I consider the Natchez loam, with land shells and the bones of *Mastodon* and *Megalonyx*, to be more ancient than the alluvium of the Somme, containing flint implements and the remains of the mammoth and hyæna, I must declare I do not. Both in Europe and America the land and fresh-water shells accompanying the extinct pachyderms are of living species, and I could detect no shell in the Natchez loam so foreign to the basin of the Mississippi as is the *Cyrena fluminalis* to the rivers of modern Europe. If, therefore, the relative ages of the Picardy and Natchez alluvium were to be decided on conchological data alone, the fluvio-marine beds of Abbeville might rank as a shade older than the loess of Natchez. My reluctance in 1846 to regard the fossil human bone as of post-pliocene date arose in part from the reflection that the ancient loess of Natchez is anterior in time to the whole modern delta of the Mississippi. The table-land was, I believe, once a part of the original alluvial plain or delta of the great river before it was upraised. It has now risen more than 200 feet above its pristine level. After the upheaval, or during it, the Mississippi cut through the old fluviatile formation of which its bluffs are now formed, just as the Rhine has in many parts of its valley excavated a passage through its ancient loess. If I was right in calculating that the present delta of the Mississippi has required as a minimum of time more than one hundred thousand years for its growth, it would follow, if the claims of the Natchez man to have coexisted with the *Mastodon* are admitted, that North America was peopled more than a thousand centuries ago by the human race. But even were that true, we could not presume reasoning from ascertained geological data that the Natchez bone was anterior in date to the antique flint hatchets of St. Acheul. When we ascend the Mississippi from Natchez to Vicksburg, and then enter the Ohio, we are accompanied everywhere by a continuous fringe of terraces and sand at a certain height above the alluvial plain, first of the great river, and then of its tributary. We also find that the older alluvium contains the remains of *Mastodon* everywhere, and in some places, as at Evansville, those of the *Megalonyx*. As in the valley of the Somme in Europe, these old post-pliocene gravels often occur at more than one level, and the ancient mounds of the Ohio with their works of art are newer than the old terraces of the *Mastodon* period, just as the Gallo-Roman tombs of St. Acheul or the Celtic weapons of the Abbeville peat are more modern than the tools of the mammoth-bearing alluvium. In the first place, I may remind the reader that the vertical movement of two hundred and fifty feet, required to elevate the loess of Natchez to its present height, is exceeded by the upheaval which the marine stratum of Cagliari, containing pottery, has been ascertained by Count de la Marmora to have experienced. Such changes of level, therefore, have actually occurred in Europe in the human epoch, and may, therefore, have happened in America. In the second place, I may observe that if, since the Natchez *Mastodon* was embedded in clay, the delta of the Mississippi has been formed, so, since the mammoth and rhinoceros of Abbeville and Amiens were enveloped in fluviatile mud and gravel, together with flint tools, a great thickness of peat had accumulated in the valley of the Somme; and antecedently to the first growth of peat there had been time for the extinction of a great many mammalia, requiring, perhaps, a lapse of ages many times greater than that demanded for the formation of thirty feet of peat, for since the earliest growth of the latter there has been no change in the species of mammalia in Europe."

In the loess near Maestricht, forming part of the elevated alluvial plain through which the Meuse flows, a human jaw was found at a depth of nineteen feet from the surface. In the same loess, and a few feet distant from the jaw, was found the tusk of an elephant. The valley is partially filled with loess and gravel, and patches of the former extend up the sides to a height of 200 feet above the level of the river. Nearer the river are bluffs of gravel, capped by loess, which have a height of about 60 feet. And it is near the junction of this loess and gravel that the human jaw was found. The antiquity of the jaw is probably not greater than many other human remains which have been discovered in caves and elsewhere, and we should be inclined to refer it, though not with much confidence, to the period of the second depression alluded to in the earlier part of our article.

Near Aurignac, in the department of Haut Garonne, a sepulchral grotto was discovered in 1852, filled with human bones belonging to 17 or 18 individnals of various ages. The bones were taken out and reburied in the neighbouring cemetery before a complete account of the circumstances under which they occurred was drawn up, and no one had an opportunity of carefully examining the remains. The cave, which is more fully described under CAVE, E. C. S., appears to have been used as a burial place, and its mouth closed with a large slab of sandstone, the nearest place from which it could have been brought being the opposite side of the valley. A few fossils and very few objects of human workmanship were found in the inside of the cave, but in the earthy layers outside the stone were ashes, flint implements, a stone with which the flints were shaped, bone arrows, a bodkin, and tools made from the horn of a reindeer. Scattered amongst the ashes and earth were the bones of 19 different species of herbivorous and carnivorous animals, of which those of the reindeer, aurochs, and horse were most numerous; while those of the cave-bear, cave-lion, and cave-hyæna among the carnivores, and of the mammoth, tichorhine rhinoceros, and Irish elk amongst the herbivores were less so. All the bones of the herbivores were split in a longitudinal direction, in the same way as is done by modern tribes for the sake of the marrow, and most of them were partially eaten and gnawed by the hyænas. These relics of human feasts are especially interesting, inasmuch as they afford strong presumptive evidence that man was really the contemporary of the cave-bear and tichorhine rhinoceros. Thus there has been found here the bone of a cave-bear, which has been acted upon by fire, split longitudinally for the extraction of the marrow, and gnawed by some strong-toothed carnivorous animal. The bones of a young tichorhine rhinoceros has the same marks. The nature and condition of the bones found in the interior were also remarkable. They appear to have been introduced by man. Amongst the rubbish were found ten human teeth, which had lost the same proportion of animal matter as the bones of the cave-bear and tichorhine rhinoceros with which they were associated. A tusk of the cave-bear was carved in imitation of what looks like a bird's head. None of the bones in the interior were broken, or gnawed, or burnt, but from their juxtaposition in many instances, the portions of animals were evidently introduced with the flesh on. Thus in one spot most of the bones of a cave-bear were lying together uninjured. Many of these facts, if isolated, would not necessarily prove the contemporaneity of man with the extinct animals mentioned, for it is possible that the bones of the tichorhine rhinoceros and cave-bear may have belonged to individuals obtained from frozen ice; and the capability of the bones to be carved, together with the similarity in the amount of animal matter in the human as in the other bones, is also consistent with the same idea; but the fact that the flesh was first eaten, the bones broken, and the broken fragments subsequently gnawed by carnivorous animals, indicates that the man of Aurignac was the contemporary of such carnivorous animals. In this case it is highly probable one of those carnivorous animals was the cave-hyæna, for its remains are there—the bones are gnawed and eaten in a way that is characteristic of those which are so frequently associated with this species, and its dung is plentifully mixed with the earth outside of the cave. If, then, it is admitted that the cave-hyæna was prowling about Aurignac during the period when this old sepulchral grotto was being filled with its dead, there is strong reason for believing man also co-existed with the tichorhine rhinoceros and cave bear. And this admission removes much of the difficulty in accepting the conclusion that these species were also living at the time of the valley gravels of such rivers as the Somme, since as has been shown under CAVES, E. C. S., the filling of the Aurignac grotto is far more recent than those gravels. This old grotto is further interesting on account of the unworked flint implements, the carved bones, the ornaments, such as a bracelet of cockle-shells, and the supply of fresh food which seems to have been laid beside the dead. On seeing these objects, thus associated, they speak to us in that kind of living language in which the tongue takes no part, but in which the ideas are as it were transmitted through them from mind to mind. "If," says Sir C. Lyell, "we have before us at the northern base of the Pyrenees a sepulchral vault, with skeletons of human beings consigned by friends and relatives to their last resting-place, if we have also at the portal of the tomb the relics of funeral feasts, and within it indications of viands destined for the use of the departed on their way to a land of spirits; while among the funeral gifts are weapons wherewith in other fields to chase the gigantic deer, the cave-lion, the cave-bear, and woolly rhinoceros, we have at last succeeded in tracing back the sacred rights of burial, and, more interesting still, a belief in a future state, to times long anterior to those of history and tradition. Rude and superstitious as may have been the savage of that remote era, he still deserved, by cherishing hopes of a hereafter, the epithet of 'noble,' which Dryden gave to what he seems to have pictured to himself as the primitive condition of our race—

> "as Nature first made man,
> When wild in woods the noble savage ran."

The grotto at Aurignac is but one out of many (we might almost say hundreds of) caverns in the south of France, the contents of which bear testimony to a population who had arrived at a remarkable stage of civilization for so early a date. Without any knowledge of the use of metals, they were able to make a great variety of implements in bone, ivory, and reindeer horns, many of which are sculptured, nay, in some cases carved with an elegance and accuracy unknown among the nations of Western Europe until several centuries after the commencement of the Christian era. Amongst these figures there is one of a bear which differs from that of the common brown bear, but offers peculiarities which suggest that it was intended for the cave-bear. It is made upon a flint. There is also a figure of an elephant, different from any existing species, designed upon a reindeer's bone. This last was discovered in the cavern of Bruniquel in which well-shaped bone needles were plentiful, and in which has been found a remarkable cranium. This skull is said (Broca in Anth. Rev. vi. p. 243) to be distinguished by the purity of its form, the gentleness of its contours, the slight prominence of its apophyses, the little depth of its muscular marks, all of which are characters incompatible with the violent manners of a savage or barbarous race. This people appear to have flourished during a considerable period, and to have been ultimately conquered by a race who possessed more perfect weapons, who introduced the art of polishing flint, but who possessed little industry and no notions of art. At any rate this is one explanation that may be given for the circumstance that there appears to have been a sudden transition from the time of the people who designed figures and used chipped flint instruments, to those who used polished implements, but who have left no signs of art comparable with those left by the men who preceded them. In the present state of our knowledge it seems exceedingly hazardous to venture any opinion as to who these people were; but the few glimpses we have of their mode of life, physical conformations, religious notions, weapons, and customs, at once remind us of the modern Esquimaux. It is surprising what a flood of light a knowledge of the Esquimaux throws upon the curious facts revealed to us respecting the old nations of France. The parallel obtains not only between their manners and other points referred to, but also between the climates and faunas which are associated with both the ancient and modern men. The full resemblance could only be conveyed by details for which we cannot find room here, but although scarcely connected with our subject a few parallel examples may be cited. The caverns in which the men of France are found are characterized by the presence of the reindeer, and hence they are said to belong to a reindeer period. Greenland and the Arctic regions where the Esquimaux dwell is at the present time the country of the reindeer. The reindeer people used a peculiar oval form of flint implement which is almost identical in shape with the implements used by the Esquimaux for scraping the skins from which they make their clothes. In preparing these skins the natives masticate them, and hence their teeth are worn down to the stumps at an unusually early age. In some of the skulls from the French caverns the teeth present a similarly worn condition in comparatively young individuals. The Esquimaux had no knowledge of pottery or iron when first visited by more civilized nations, and the reindeer people also appear to have been ignorant of them. The Esquimaux used bone needles, which could not, we believe, be distinguished from those found in the caverns of South France. The dwellings of the Esquimaux are exceedingly disgusting from accumulated filth, and from the heaps of bodies which they pile up for the winter's supply. A similar habit appears to have prevailed amongst the reindeer people, and Mr. Christy especially alludes to the accumulation of animal remains as evidence that the climate of the south of France was at one time similar to that of Arctic regions; since in any but a cold climate such deposits would rapidly become a mass of decomposition. Parry notices that he saw a few human bones lying amongst the relics of former meals. Garrigou, on the other hand, has found human bones in the caves of South France on which exist methodical percussive marks made for breaking the bone so as to obtain the marrow. The Esquimaux have a great natural ability for drawing, and this we have seen was also the case with the reindeer folk. The following passage from Lubbock's 'Prehistoric Times,' is especially interesting when taken in connection with the burial-place at Aurignac. "According to Corantz, the Greenland Esquimaux 'have neither a religion nor religious worship, nor so much as any ceremonies to be perceived tending towards it.' This statement has been confirmed by many other observers. Their burial ceremonies have, however, been supposed to indicate a belief in a resurrection. They generally bend the body into a sitting posture, bringing the knees up under the chin, and then wrap the corpse in one of their best skins. For the grave they chose some high place, and over the corpse they make a heap of stones. Near the body some of them place the implements of the deceased, and even sometimes, if he was a man, his kajak, believing, as it has been said, they will be of use to him in the new world. Egede, however, expressly denies that it is done with any such idea." When a person is dying they place him or her in one of the huts along with food and drink, and other things that will soothe their last moments, and shut them up. They have a superstition that any weight upon a corpse gives pain, which belief, Lubbock remarks, would give rise to a vaulted tumuli in more favoured countries, but in the north the bodies are so slightly covered up that the bones are soon unearthed by foxes and dogs, and become scattered about the dwellings. The squatting posture is very frequent in the earlier tumuli of Western Europe, and from the dimensions of the cave at Aurignac the skeletons were probably also arranged in the same way. The Esquimaux are a remarkably peaceable people, and are said neither to possess warlike weapons nor indeed to know what war is, and the same peculiarity seems to have prevailed amongst the reindeer folk. In making these comparisons we do not wish to imply that these customs and similarity of ideas are found only in the people of these two regions; nor that the reindeer folk did not differ in many respects from the Esquimaux; nor that the Esquimaux are the descendants of the reindeer folk; but simply to indicate that there is much to be seen and heard amongst the Esquimaux which will enable us the better to appreciate the objects and phenomena which are met with in the caves of South France.

The next specimen to which we would draw attention is a human skeleton which was found in the loamy floor of a cave in the Neanderthal near Dusseldorf, but of which only a portion of the cranium, and a few of the longer bones, have been preserved. No fossils nor articles of human workmanship were found in the loam whereby some clue might be obtained as to its probable age. The cave is a basin-shaped hollow which was filled with the loam by a rent connected with the surface of the country, and is about sixty feet above the level of the river Düssel. It has been said that the skeleton is of immense antiquity, and by some it has been looked upon as one of the earliest relics of humanity. At present, however, it seems to us that its age is quite undetermined, and all that can be safely said on the point is that it is probably more than a few centuries old. The calvarium, or skull-cap, has been the subject of much discussion, and has been regarded by some as the missing link between man and the apes; by others as the most brutal of all known human skulls; by others as that of an idiot; and by yet another as a distinct species of man under the cognomen of *Homo neanderthalensis*. The general impression left upon the mind after a perusal of the discussion is that its characters are individual rather than distinctive of a nation or race of men; that it belonged to a man who had as large a brain as many of the least intelligent races which are now in existence, and a strong muscular development. The prominent bony ridge over the eyes, the low retreating forehead, and the other features which are seen in it, are such as would arise from an abnormally early closing of some of the sutures. It is usually considered to have most resemblance to the skull of Australians; but there is as great, perhaps a greater, similarity between it and some of the skulls of modern Frenchmen and Irishmen.

The skull from the Engis cavern, about eight miles from Liège, and now in the museum of the university of that place, was imbedded in a breccia which contained the bones of horse, reindeer, and rhinoceros. There are no good data whereby to ascertain the time when the individual to whom it belonged was living, but it may be conjectured to have been, with some degree of probability, at about the same period when the men of Aurignac flourished, or perhaps a little earlier. Its narrowness in front, and its general conformation, indicate that it belonged to a woman of ordinary intelligence. Human bones of considerable antiquity have also been found in the caves at Bize and Poudres, in the conglomerate of the Florida reef, in the lake-dwellings of Switzerland, and in the peat bogs of various parts of Europe. The conglomerate in which the human remains occur in the Florida reef is estimated to be 10,000 years old by Professor Agassiz; and a human skeleton found by Dr. Dowler beneath four buried forests, superimposed one upon the other, in the delta near New Orleans, is said to have lain there for 50,000 years. We believe that, in the present state of our knowledge, attempts to estimate the age of the human race in years is premature, and that all the statements which assign from 6000 to 250,000 or more years as the time which has elapsed since certain individuals ceased to exist require revisal. On the whole, it appears probable that man co-existed with many of the extinct mammalia, with whose remains his own are associated; but notwithstanding all that has been said and written, we do not know even one fact which thoroughly establishes this point. The phenomena which are generally appealed to as positive evidence in favour of this position, appear to us to prove nothing more than that man co-existed with the dead bodies of these species with the flesh on their bones, but it is possible that they may have died ages before. The case of the gnawed bones of the Aurignac grotto would go far to prove contemporaneity if it is certain that it was the cave hyæna which gnawed them; but although it is admitted that the probability is great that it was the hyæna, still the facts are capable of a different interpretation. It may also be urged that it is very unlikely that the reindeer folk would eat the ice-preserved remains of cave bear and tichorhine rhinoceros so long as the country abounded in living reindeer, horses, and oxen; nevertheless, the assertion that they may have done so does not seem to be untenable. It may be admitted that man lived when the gravels of many of the river valleys of France, Great Britain, and other countries, were deposited; but the age of these cannot be, nay, rather has not been, determined with any approach to accuracy when estimated in years. From a geological point of view, the oldest traces of man appear to be of post-glacial date, and to belong to the time of the second post-pliocene depression, when the middle regions of Europe were liable to frequent and extensive inundations. We are aware that some of the relics or traces in caves have been assigned to the pre-glacial, and even to the pliocene, period; but the reader is referred to CAVES, E.C.S., for the evidence upon which this belief is founded.

The celebrated jaw-bone from the gravel of Moulin Quignon, and a few inches only above the chalk, has led to much discussion; but the facts which were elicited have not entirely cleared away the suspicion that this and the other human bones which have since been found on the same horizon, may not be so old as has been supposed. Another human fragment of a lower jaw of great antiquity, presenting several remarkable characters, and the authenticity of which is unquestioned, has been found in the Naulette cave near Dinant. In solidity and massiveness it far surpasses the average, and is especially remarkable in having no chin, no tubercles on the inside where the two rami coalesce, as also in possessing highly developed canine and molar teeth, which gradually increase from before backwards. A similar jaw, of apparently the same antiquity, has turned up in the Arcy cave. Broca's conclusions respecting the Naulette jaw, as compared with human jaws generally, are, that in the white man the molars gradually decrease in size from the first to the third; the molars of the Australian are very nearly equal; while in the Naulette jaw there is a sensible increase in their volume from before to behind, a feature which is still more developed in the chimpanzee. The prominence of the chin is well displayed in the white man, is not so decided in the Australian, is just perceptible in the Arcy bone, while in the Naulette jaw it is absent, and in the chimpanzee there is a backward slope. The relative height of the lower jaw decreases by successive gradations from the white man to the chimpanzee, and on the other hand the thickness increases, being least in the white man and greatest in the chimpanzee. The mandibular tubercles are conspicuous in the white man, just perceptible in the jaw from Arcy, while in the Naulette bone there is a shallow pit, and not a projection, and the chimpanzee has a deep pit. A calvarium, believed by its discoverer to be pre-glacial, has been exhumed from a lake marl, exposed in a railway cutting at Olmo, near Arezzo. It possesses characters which have not hitherto been found in any human skull. It is dolichocephalic, and is said to approach the negro form of skull more than any other. Some skulls found in the Belgian caves from deposits of the reindeer period, indicate that the Belgian people of that age had brachycephalic crania and angular squarish faces, precisely like those possessed by the Mongolians of the present day. The human jaw-bone, and other osseous remains from the Bruniquel cave, are also assigned to the reindeer period.

Among the most interesting of human remains are those from the cave of Les Eyzies, the general contents of which belong to the reindeer period. The skulls to which we are about to allude were found in the lowest part of the cave, and at a lower level than the remarkable carved objects associated with reindeer bones which have been obtained from that cave. We should be disposed to refer the skulls to the same period, but Professor Broca thinks they are of higher antiquity and approximate to the time of the mammoth. These skulls are in marked contrast with those from the Belgian caves, both as regards form and volume; and along with them were found limb bones of most remarkable character. The old cave men of Les Eyzies were above the average stature of the present day, and these skeletons indicate that some individuals at least were possessed of amazing strength. The femur of one old man was so thick and massive that Professor Broca was unable to find one to match it in any of the Paris collections. This femur, as well as those of other males, have well developed ridges and roughened surfaces indicative of powerful muscles. The tibiæ are remarkable for their flattened, but straight, form, a form which is unusually frequent in the oldest known tibiæ. It has been noticed in the men of the Gibraltar caves, and amongst living people it is probably most prevalent in negroes and North African tribes, although in them the flatness is not so great as in the prehistoric men. The skulls from Les Eyzies present a curious combination of characters, some of which are now almost entirely restricted to the lowest existing savages, while others are considered to be characteristic of the most civilized nations of modern times. Thus the skull of one individual, the old man whose femur has just been alluded to, has a capacity far above the average of modern Frenchmen and Englishmen. The forehead is high and well-developed, and is such as would ordinarily be assigned to an intelligent individual. The large size of the cranium approximates the Les Eyzies people to the men of the oldest British tumuli, whose skulls are of extraordinary dimensions. The cranial sutures were effaced from the front, backwards, as is the case with all living savage races. Professor Broca thus contrasts the antithetical characters of the skeletons of Les Eyzies:—"The great capacity of the brain, the development of the frontal region, the fine elliptical form of the anterior part of the profile of the skull, the orthognathic disposition of the superior facial region (from which arises a considerable enlargement of the facial angle of Camper) are incontestable characteristics of superiority, such as we are accustomed to meet with only in civilized races. On the other hand, the great breadth of the face, the alveolar prognathism, the enormous development of the ascending ramus of the jaw, the extent and roughness of the surfaces for the insertion of muscles, and especially of the masticators, suggest the idea of a savage and brutal race; and we are led to suspect that the woman has been slain by a blow with a hatchet, and that the thigh bone of the old man bears traces of an old and serious injury. Examine, again, the simplicity of the sutures, and their probably equally simple obliterations, which pass from before backwards, as is the case with barbarous people. Let us add, that the shape of the bones, and, in particular, the extraordinary development of the ridge of the femur, indicate a high degree of muscular power. Let us review these characteristics—the excessive breadth of the ramus of the jaw; the subcoronoidal curvature of the ulna, of which the coronoid cavity is extremely shallow, and, above all, the flattening of the tibiæ, which are more or less manifestly simious; and we shall thus complete the picture of a race which, in some of its characteristics, attained the highest and noblest degrees of human morphology, and in others descended even below the most degraded anthropological types of the present day." ('Transactions of the Third Session of the International Congress of Prehistoric Archæology,' p. 172.) It is thought that such oppositeness of character is related to the habits of the people, who must have had great muscular development in order to maintain their ground amidst the barbarous people of their time, and a high mental organization to develope those artistic results which indicate an intelligent and perfectible race—a race which Professor Broca says is entirely different from any other known to him. The men of the Gibraltar caves explored by Busk and Falconer, do not seem to belong to the most remote antiquity, but we would notice them since they had femurs and tibiæ of precisely the same extraordinary type as those of the Les Eyzies individuals, combined with skulls of a high type identical with that of the crania from Guipuscoa, which Professor Broca terms Basque. One of the largest accumulations of human skeletons of the reindeer period is that found at Solutré in the department of Saône-et-Loire. The skulls are said by Pruner-Bey to have the lozenge-shaped face so frequent amongst Mongolians, and to be divisible into four principal types corresponding to the four principal nations of the high northern regions of Europe. Thus he distinguishes the Lap type, in which the head is brachycephalic and round; and the skeleton slender and small. The Finnish type, in which the head is of moderate length, or mesaticephalic and round; and the skeleton massive and tall. The Esthonian type, to which the Eyzies skulls belong, and in which the cranium is highly dolichocephalic; and the Esquimaux type. Associated with these are others of intermediate characters. The fact that these skulls correspond with those of the Mongolian division of mankind is noticeable, since a large proportion of the crania assigned to the reindeer period have a similar correspondence. Amongst other prehistoric remains of man, which may be of great antiquity, we would mention the fragments of jaw found in the excavations on Therasia, an island forming one of the oldest portions of the Santorin volcanic group. As these were associated with the remains of a house, coarse decorated pottery, implements of flint and obsidian, and a bead of gold, their apparent age, although prehistoric, will not be anything like so remote as most of the human bones we have noticed. The older portion of the volcanic deposits constituting Therasia are believed to have been formed in the newer pliocene period.

We have purposely confined ourselves to a notice of the principal oldest human remains; consideration of space forbids long details on the men of the polished stone and subsequent periods, on the animals which flourished during those periods, or on the tools, weapons and other articles of human fabrication which illustrate the habits and customs of the pre-historic peoples. Neither can we say much for or against the probability that the chronological dates assigned to them are correct. Suffice it to say, that the most reasonable estimate is that which places the introduction of iron into Western Europe at approximately 2700 years ago, the beginning of the bronze period at about 4000 years, that of the neolithic age at about 6000 years, that of the reindeer period somewhat over 7000 years, and the date of the earliest men at a period still more remote.

MARSILEACEÆ [E. C. vol. iii. col. 690]. Lindley considered this group to be an order. Some more recent authorities have regarded it as a family allied to the Lycopods, while others have separated it into two families, named, respectively, *Marsileaceæ* and *Salviniaciæ;* while yet others again maintain that *Azolla* forms the type of a third family. Duchartre makes the whole group a family of the acrogenous cryptogams, intermediate between the ferns and the grasses, the last group being placed at the base of the phanerogams. The fructification of the principal genera has long been known; but it is only recently that the special structure of the generative organs has been adequately understood. *Pilularia* is noticed under PILULARIA, E. C., to which account we here give a few supplementary details, as also a notice of *Marsilea* and *Salvinia.*

Pilularia, which contains other living representatives than *P. globulifera,* reproduces by means of sporocarps placed at the axils of the more or less developed leaves. Each sporocarp is divided by partitions into four cells. On the inner face of each cell is an elongate and slightly prominent placenta, to which is attached a congeries of small transparent bodies, which themselves contain a number of granules floating in a gelatinous fluid. These granules have two membranes, the exterior of which is so far incomplete as to allow the inner one to project as a small protuberance. When the latter subsequently opens it liberates minute cells with antherozoids, and hence these granules perform the functions of antheridia. The same placenta supports from 12 to 20 ovoid bodies, large as compared with the granules from which the ovules are destined to germinate. Each such body consists of an inner cell, filled with amidon and drops of oil, suspended in a mucilaginous liquid. It is bounded by a tough white membrane composed of minute cells, and furnished with a terminal knob. The membrane is covered by layers of gelatinous cells. As soon as the ovules are liberated they begin to develope. This process first commences in a parenchymatous outgrowth in that part of the innermost cell which protrudes through the median membrane. This outgrowth constitutes what is called a prothallus. An isolated cell in this prothallus acquires an increased size, and fills the cavity at the base of the single archegonia which the prothallus supports. A small canal runs from this cavity to the summit of the archegonia, which terminates in three or four divergent ovules. At this period the antheridia have discharged their cellules. These soon communicate with the archegonia, and cause the development of the embryo from which the mature plant is directly derived. In general features this mode of development resembles that of the *Echinodermata* amongst animals.

The species of *Marsilea* thrive in shallow lakes, so that its habits are like those of *Pilularia.* The sporocarps are laterally compressed, and are carried on stalks continuous with the petiole of the leaf. They open by a longitudinal slit. The interior is furnished with a central partition, which runs parallel to the flattened sides, at right angles to which are a series of horizontal partitions, which divide the vessel into eight or nine chambers, one above the other. The median partition is of a mucilaginous nature at one end, and is capable of so expanding by the absorption of water as to contribute materially to the dispersion of the reproductive bodies. Each chamber has a longitudinal band attached to its outer wall, a number of antheridia in the form of clavate-pediculated sacs, and elliptical sessile ovules, the innermost cellule of which has thin walls, and is enclosed first by a thick, yellow, transparent envelope, and next by a more external coat, which is truncated at its summit, and lastly by a transparent gelatinous layer. When the sporocarp bursts the mucilaginous portions absorb water, which absorption causes the transformation of the sporocarp into a long riband, supporting the system of partitions with the band of antheridia and ovules. From these originate a prothallus, and the subsequent changes proceed as in *Pilularia.* The earlier leaves are mere filaments, but the later ones present the normal form of leaves with four pinnæ.

Salvinia embraces small plants which float on the surface of still waters, *S. natans* being the best known species. The sporocarps are sustained on descending branches, and are somewhat depressed in form. The mode of development is nearly similar to what occurs in the genera already noticed.

(Duchartre, *Elémens de Botanique.*)

MARSUPIATA [E. C. vol. iii. cols. 690—725]. The former article supplies many illustrations showing some of the main points in which this remarkable order of animals differs from the other mammalian groups. In the present article we propose to notice a few of the more curious structural details which have not been already dilated upon.

In the great majority of marsupials the spines of the cervical vertebræ are comparatively short, there being a sudden increase in the length in the first dorsal spine. The dorsal spines gradually diminish in length and increase in breadth from before to behind. In many species the dorsal and lumbar spines slope in opposite directions, those of the dorsal vertebræ being directed backwards, and those of the lumbar series forwards. The sudden accession in the length of the spines is not by itself a special marsupialian feature, but is one that is possessed by nearly all browsers and grass-eaters. It is associated with the flexible motion of the neck, and is most marked in those species which have the greatest power of turning the head in all directions. The convergence of the spines is best displayed in the most active runners and leapers, and is especially well shown in the kangaroo; and is rarely observable in the other mammalian orders. The decreasing size of the dorsal spines is as prevalent in marsupials as is the curvilinear outline of the same processes, due to their lengths first increasing and then decreasing, in those placental mammals which have an abrupt succession of long dorsal to short cervical spines. In the latter group this arrangement is associated with the high shoulders and humps, which may be exemplified by the horse, the giraffe, and the elephant. The number of the true vertebræ is constant, viz., 26; but there is a difference in the proportions in which they form the lumbar and dorsal portions of the column. In all cases there are seven cervical vertebræ; in some species the dorsal vertebræ, or those to which ribs are attached, are 12 in number, as in *Petaurus;* in others 13, and in the wombat there are as many as 15. Generally speaking, the most agile species have the fewest dorsals and the smallest thorax, while the heavier and slower forms have the greatest number of dorsals and the longest thorax. In the active kangaroo, for instance, there are 13 ribs on each side, of which the seven anterior ones are connected with a sternum, while the extremities of others are free. In the wombat there are 15 pairs of ribs, of which the six anterior pairs articulate with a sternum, and the remainder are attached to one another by hæmapophyses or connecting cartilages. The wombat's thorax is thin, unusually massive, long, and well braced. This extra protection of the soft viscera seems requisite in an animal which burrows in the ground, and whose trunk must frequently be subjected to immense pressure. The same modification of structure occurs in the mole and in *Chlamyphorus truncatus,* both of which are active burrowers. This feature is remarkable when the marsupialian forms are compared with their nearest allies; but there is less contrast when comparison is made with the orders higher in the zoological series, since on the average the latter have a better protected thoracic region than the former. In most marsupials there are only two sacral vertebræ, though some species have three, and a few have four; while in *Perameles* there is one only. In the wombat, which has a very short sacrum, the hindermost vertebræ of the pelvic region are anchylosed together, so that it is difficult to determine how many are sacral. This part of the body has a firmness, which seems generally to pervade this extraordinary creature. In the other mammalian orders the usual number of sacral vertebræ ranges from three to six. The number of caudal vertebræ is exceedingly variable in marsupials, in which respect this group resembles other mammalia. The *Chœropus* seems to have no tail; the *Koala* has a very short one; that of the wombat is not conspicuous in the living animal, and is composed of 12 vertebræ at the most, of which six only project beyond the pelvis. In most other species the tail is of considerable length and the vertebræ numerous, but there is no relation between the length and the number of bones. In *Perameles* there are from 18 to 23 caudal vertebræ; in *Hypsiprymnus ursinus* more than 26; the kangaroos have between 20 and 30; and *Didelphys carnivora* 31. Most of the species which have long tails, more especially such as use that organ for purposes of prehension or of support, have bony processes attached to the under side of the caudal vertebræ, which serve to protect the nerves and blood-vessels from injury by pressure; and at the same time afford surfaces to which may be attached the powerful muscles by which this appendage is moved. These V-shaped bones, or hæmapophyses, are shown in the figure of the kangaroo, E. C. vol. iii. col. 713. They are rarely met with in other mammalian orders, and when they do are found in animals which use their tails for similar purposes as the marsupials. Thus the great ant-eater has these bones, and it frequently uses its tail as a basis of support in order that it may make better use of its forelimbs in attacking an enemy or demolishing an anthill. The kangaroo also, when driven to bay, supports itself on a tripod formed by the tail and two hind-limbs, and hugs its foe in its powerful forearms. So again the spider-monkeys, which use the tail as a fifth extremity in climbing, are provided with these protective bones, but other processes share in the same functions; and many other long-tailed monkeys have the same parts more or less developed.

The skulls of marsupials present a great variety of form, structure, and adaptation of purpose, according to the prevalent habits of the species. A very small proportion of the skull is specially devoted to the protection of the brain, the great bulk of the bony matter being more intimately connected with the sense organs and mastication. Thus in the wombat, the koala, the phalangers, the *Dasyuridæ*, and many of the opossums, the facial portion anterior to the zygomatic arches occupies one-third the entire length of the skull; in *Thylacinus* it is nearly one-half; in many of the kangaroos it is fully one-half; and in the arboreal *Hypsiprymni* it is even more than this. In the predaceous and stronger species the modelling of the cranium is bolder, owing to the development of ridges and impressions whereto the muscles can be attached; while the herbivorous and weaker species have the smoother skulls. The relation of the breadth to the length varies from three to four to one to two; the former proportion occurring in the wombat and *Petaurus;* the latter in *Perameles.* The height also varies. Thus in some species of *Petaurus* the length is nearly twice and a half the dimensions of the height, while in koala the height is fully three-fourths of the length. In most species the width tapers from behind forward, but in the extinct *Nototherium* the facial portion of the skull is broader than the cranium itself. The ridges are frequently as highly developed as in the most carnivorous mammals. The Virginian opossum has a sagittal crest proportionally larger even than that of the strong-jawed hyæna. In such species as *Petaurus sciureus* and *Myrmecobius fasciatus,* the outside of the calvarium is comparatively smooth, the temporal muscles even originating in a slight depression. The zygomatic arches are on the whole well developed, and in some species are remarkably bony and massive; but there is not the same relation between the nature of the food and the strength of these arches as is displayed in the placental mammals, since some of the grass-eating marsupials have very strong arches. Professor Owen correlates this, in the case of kangaroos, with the circumstance that the grass they feed on is very dry and rigid, necessitating a stronger apparatus of bone and muscle for working the terminal teeth than would be required in cases where the grass is soft and succulent. The arches of the insectivorous marsupials are weaker than those of kangaroos, but they are relatively stronger than those of placental mammals which have similar habits and diet. In the koala they are remarkably long, deep, straight, and parallel. The frontal bones are larger, but they serve to enclose far more of the nasal than of the cerebral cavity, in which they differ most widely from the highest placentals, such as man and the apes. The lacrymal bones enter largely into the composition of the face, as is also the case, though less generally, in some other orders, such as *Rodentia,* while it is exceedingly rare for them to extend beyond the orbit in the *Carnivora, Quadrumana,* and some other orders. The malar bones are very strong and large amongst marsupials generally, and in *Perameles lagotis* they are bifurcated at both extremities. The palatine apertures are more general and larger in marsupials than in any other mammalian order; in which respect they somewhat approach reptiles and birds. The following remarks by Professor Owen will indicate generally the variation in their sizes and numbers: "In *Phalangista Cookii,* in *Petaurus flaviventer* and *Petaurus sciureus,* in *Macropus major,* and some other great kangaroos, the bony palate is of great extent, and presents a smooth surface, concave in every direction towards the mouth; it is pierced by the two posterior palatine foramina at the anterior external angles of the palatine bones, either within or close to the transverse palato-maxillary sutures. Behind these foramina, in the kangaroo, there are a few small irregular perforations. The bony palate is similarly entire in the *Hypsiprymnus ursinus.* In *Macropus Bennettii* there are four orifices at the posterior part of the bony palate. The two anterior ones are situated upon the palato-maxillary suture, and are of an ovate form with the small end forward. The two posterior foramina are of a less regular form and smaller size. In the brush kangaroo (*Macropus Brunii,* Cuv.), the posterior palatal foramina present the form of two large fissures placed obliquely and converging posteriorly. They encroach upon the posterior borders of the maxillary plate. Anterior to these vacancies there are two smaller foramina, and posterior to them are one or two similar foramina. In the potoroos, wombat, and koala, the posterior palatal openings are large and oval, and situated entirely on the palatal bones. In *Hyps. setosus* they extend as far forward as the interspace between the first and second true molars; in *Hyps. murinus* they reach to that between the second and third true molars; posterior and external to these large vacuities there are two small perforations. In the phalangers, with the exception of *Ph. Cookii,* the palatal openings are proportionally larger; they extend into the palatal process of the maxillaries, and the thin bridge of bone which divides the openings in the potoroo, &c., is wanting: the two perforations at the posterior external angles of the palatine bones are also present. In the Virginian opossum the bony palate presents eight distinct perforations, besides the incisive foramina; the palatal processes of the palatine bone extend as far forward as the third molars; a long and narrow fissure extends for an equal distance (three lines) into the palatal processes both of the palatines and maxillaries; behind these fissures and nearer the median line are two smaller oblong fissures; external, and a little posterior to these, are two similar fissures, situated in the palato-maxillary sutures; lastly, there are two round perforations close to the posterior margin of the bony palate. In the Ursine Dasyure a large transversely-oblong aperture is situated at the posterior part of the palatal processes of the maxillary bones, and encroaches a little upon the palatines. In Mauge's Dasyure there are two large ovate apertures crossing the palato-maxillary suture, separated from each other by a broad plate of bone; posterior to these are two apertures of similar size and form, which, being situated nearer the medial line, are divided by a narrower osseous bridge; each posterior external angle of the bony palate is also perforated by an oval aperture. In the Viverrine Dasyure the two vacancies which cross the palato-maxillary suture are in the form of longitudinal fissures, corresponding to the fourth and fifth grinders; the posterior margin of the bony palate has four small apertures on the same transverse line. Since the defective condition of this part of the cranium is one of the characteristics of the skull of the bird, it might be expected that some approximation would be made to that structure in the animals which form the transition between the placental and oviparous vertebrates. We have already noticed the large vacuities which occur in the bony palates of nearly all marsupials; but this imperfectly ossified condition is most remarkable in the *Perameles lagotis,* in which the bony roof of the mouth is perforated by a wide oval space from the second premolars to the penultimate molars, exposing to view the vomers and the convolutions of the inferior spongy bones in the nasal cavity." The peculiar features of the lower jaw have already been described in E. C. in connection with the discussion as to the marsupial or non-marsupial nature of the fossil mammalian remains from the Stonesfield slates. The bones of the former are generally strong and well-developed; and are so articulated as to admit readily of pronation and supination, motions which are required by animals which use their fore-limbs for opening the pouch. The pelvis is of an enormous size in most marsupials, as compared with the dimensions of the new-born young. Even in the species which have the smallest pelvic canal, the aperture is six times wider than the head of the embryo at birth. The separate elements are usually firm, articulated or co-ossified together, and do not admit of that lateral play which is so essential or requisite in the higher mammalia, more especially man, in which the head of the young one can sometimes be made to pass the pelvic canal with great difficulty. The marsupial bones vary greatly in size, being half an inch in length only in *Myrmecobius*, and so long, flat, and broad in koala as to approach the iliac bones in volume. They do not seem to be required for expelling the fœtus, as has been maintained by some, since of all animals the marsupials least require such an auxiliary; moreover, they are as well developed in the males as in the females. Their function is more intimately related to the action of the muscles which compress the abdomen.

The muscles in the limbs of marsupials present many modifications as regards size, number, and modes of insertion. They are generally strong and powerful, and so attached as to facilitate the pronation and supination of the limbs, a feature which is absent in the *Rodentia*, *Carnivora*, &c., but which is so highly developed in man.

The brain is small throughout the order, being relatively largest in the smaller species, and varying from $\frac{1}{250}$th part by weight of the body, as in *Dendrolagus inustus*, to $\frac{1}{800}$th part, as in the large kangaroo. The cerebellum is exposed in all, and the optic lobes, and the cerebral hemispheres are rarely convoluted, and even when convolutions are present they are very slight. The other characteristics of the marsupial brain are the large proportional anterior commissure, and still larger hippocampi, the rudimentary condition of the transverse commissure, and the small size and inferior position of the corpus striatum relatively to the hippocampus.

The tongue is well developed, and possesses considerable mobility. In many species it is richly clothed with papillæ, indicating that taste aids largely in the discrimination of food. The great development of the nasal cavities has already been noticed; and this is connected with an extensive pituitary membrane and numerous olfactory nerves. Some species of kangaroos are noted for acuteness of smell.

Marsupials have two sets of teeth during their lifetime, and hence they belong to the diphyodont assemblage. All species have incisors, but variable in number. The canines are large in the dasyures, small in the phalangers, absent in the lower jaw of the koala, and in both the jaws of the kangaroos and wombats. The number of molars is usually seven on each side of each jaw. The details of the dentition of many genera will be gathered from the E. C. article. In the thylacine and dasyures we have the carnivorous modification of dentition, but this differs from that of the placental carnivores in the greater number of the incisors, the greater uniformity and simplicity of the molars, and in the canines of the lower jaw being received into hollows of the premaxillary, and not projecting outside of it. The *Myrmecobius* has a greater number of molars than any other marsupial, as indicated by the following formula :—

Incisors, $\frac{4-4}{3-3}$; canines, $\frac{1-1}{1-1}$; premolars, $\frac{3-3}{3-3}$; molars, $\frac{6-6}{6-6}$ = 54.

There is greater evenness in the heights of the teeth; even the canines do not project much beyond the general level of the molars. In the extinct *Thylacotherium* the number was still greater, the dentition of the lower jaw corresponding with that of *Myrmecobius*, with the addition of three premolars on either side. In *Phalanger* and *Petaurus* the dental series is at first complete, but as some of the teeth are but little, they soon fall out and leave gaps. Amongst these teeth considerable variation occurs, but the permanent ones are usually very constant. Modifications in the unimportant teeth are not correlated with any general change of diet or habit. This is the explanation for the great gaps in the dental series of *Hypsiprymnus*, *Macropus*, and others, and the corresponding paucity of teeth. In *Hypsiprymnus* there are only two lower incisors, no lower canines, and only one premolar on each side of each jaw. This premolar is remarkable for its large size, being much larger than any of the molars, and for its trenchant shape. In *Macropus major* there are no canines at all, although the germs of these teeth are present in the fœtus. In the wombat we have the extreme divergence from the typical form, upon which Professor Owen makes some interesting observations, which we cite, as also his remarks on the dentition of *Thylacoleo* and *Plagiaulax*. We give his own views respecting the latter genera, because in a subsequent article [PLAGIAULAX, E. C. S.] we have inserted Dr. Falconer's views, which are opposed to those of Professor Owen. "In this genus [*Phascolomys*] the dental system presents the extreme degree of that degradation of the teeth, intermediate between the front incisors and true molars, which has been traced from the opossum to the kangaroos; not only have the functionless premolars and canines now totally disappeared, but also the posterior incisors of the upper jaw, which we have seen in the koala and potoroo to exhibit a feeble degree of development as compared with the anterior pair; these, in fact, are alone retained in the dentition of *Phascolomys*. The dental formula of the wombat is thus reduced both in number and kind to that of *Rodentia*.

Incisors, $\frac{2}{2}$; canines, $\frac{0}{0}$; premolars, $\frac{1-1}{1-1}$; true molars, $\frac{4-4}{4-4}$ = 34. [See fig. in E. C. iii. col. 715.]

The incisors, moreover, are 'dentes scalprarii,' but are inferior, especially in the lower jaw, in their relative length and curvature to those of the placental *Glires*; they present a subtriedral figure, and are traversed by a shallow groove on their mesial surface. The premolars present no trace of that compressed structure which characterises them in the koala and kangaroo, but have a wide oval transverse section—those of the upper jaw being traversed, on the inner jaw, by a longitudinal groove. The true molars are double the size of the premolars; the superior ones are also traversed by an internal longitudinal groove; but this is so deep and wide that it divides the whole tooth into two prismatic portions, with one of the angles directed inward. The inferior molars are in like manner divided into two triedral portions; but the intervening groove is external, and one of the facets of each prism is turned inward. All the grinders are curved, and describe about a quarter of a circle. In the upper jaw the concavity of the curve is directed outward; in the lower jaw, inward. The false and true molars, like the incisors, have persistent pulps, and are consequently devoid of true fangs, in which respect the wombat differs from all other marsupials, and resembles the extinct *Toxodon*, the dentigerous *Bruta*, and herbivorous *Rodentia*. A retrospect of the modification of marsupial dentition shows them to be divisible into two classes—one, 'polyprotodont,' or characterised by several pairs of mandibular incisors; the other 'diprotodont,' or by a single pair. These are large, more or less procumbent, and ever growing; the incisors of the first group are small, and of the usual limited growth. The polyprotodont type prevails in the American genera; the diprotodont obtains in the majority of the Australian marsupials, and is associated usually with vegetarian or promiscuous diet. There did exist, however, coeval with *Diprotodon*, *Nototherium*, &c., in a tertiary age in Australia, a carnivorous marsupial, equalling the lion in size, with the diprotodont type of dentition, adaptively modified for preying on the huger contemporaneous *Herbivora*. The pair of incisors in the lower jaw of *Thylacoleo* and their homotypes above were canines in size and shape; a single tooth of the molar series on each side of both jaws was concomitantly modified to act as a 'sectorial,' or flesh-cutting tooth, the crown being narrow or compressed, long antero-posteriorly, with the sides marked by vertical folds or grooves, and converging to a rather oblique cutting edge; that of the upper blade playing on the outside of the lower one. These 'sectorials' were larger than in the lion or tiger, and were even more carnassial as wanting the tubercle, and consisting wholly of the blade. Behind the upper sectorial is one small tubercular of the relative proportion of that in *Felis*; the lower sectorial is followed by two small teeth, with subtuberculate crowns. The teeth between the carnassials and laniary incisors are too small for definite use. So far as present fossils shew, the dentition of *Thylacoleo* was :—

Incisors, $\frac{3-3}{1-1}$; canines, $\frac{1-1}{0-0}$; premolars, $\frac{2-2}{2-2}$; molars, $\frac{1-1}{2-2}$, = 24.

The chief business of the teeth was delegated to the tusks and carnassials; development was concentrated on these at the cost of the normal or typical dental series. The foremost seized, pressed, lacerated, or killed; the carnassials divided the nutritive fibres of the prey. *Thylacoleo* exemplifies the simplest and most effective dental machinery for predatory life known in the mammalian class. It is the extreme modification to this end of the diprotodont type of *Marsupialia*. The skull exhibits all the concomitant carnivorous modifications in a like extreme degree. It is interesting to note that, just as the exceptional modification of the polyprotodont type in the modern *Myrmecobius* was manifested by *Amphitherium* in oolitic times, so likewise was the zoophagous diprotodont modification, but on a smaller scale than in *Thylacoleo*. The lower incisor in *Plagiaulax* was a large upcurved pointed tusk; the carnassial was of great fore and aft length, coupled with narrowness, and an oblique cutting edge, rendered sub-serrate by the better marked and more oblique lateral grooves than in *Thylacoleo*. Anterior to the carnassial there are two or three similar and smaller sectorial premolars in *Plagiaulax*, more of the general diprotodont type being retained in the older zoophagous diprotodont. Behind the carnassial are two small tuberculate molars, as in *Thylacoleo*. Some palæontologists, neglecting Cuvier's guide-post of the true molar as the light-giving tooth, have been led astray in regard to the affinities of *Plagiaulax*, referring it to the 'poephagous potoroos and kangaroos,' which combine with a single trenchant and grooved premolar four large and massive grinders of quadricuspid or transversely ridged structure." Professor Owen points out that in the diphyodont mammals the teeth are sufficiently individualised to allow of each tooth being indicated by a symbol, and its homologue traced throughout the mammalian series. The incisors, canines, premolars, and molars, are symbolised by their initial letters and a numeral, according to their position in the jaw, the order of the numbers running from 1 for that tooth of each series which is nearest the end of the snout; the milk teeth are denoted by a prefixed *d*, for deciduous. When the kangaroo first quits the pouch its dentition is, d. i., $\frac{1-1}{1-1}$; d. m., $\frac{2-2}{2-2}$, = 12. The incisors correspond to those designated by d. i. 1 in the typical dentition; and the molars to those indicated by d. m. 2 and d. m. 3. At this early stage, then, some of the teeth have germinated, and been discarded. The canines are retained by some species in the upper jaw, but are always small; but in most species they appear as germs; and then disappear without further development. Probably traces of d. m. 1 are also to be detected in the fœtus, or in the young one soon after birth. At a later stage d. i. 2 appears in the upper jaw, and d. m. 4 in both jaws, thus making the dentition, d. i., $\frac{2-2}{1-1}$; d. m., $\frac{3-3}{3-3}$, = 18. At the age of twelve months d. i. 3 is developed in the upper jaw, and m. 1 in both jaws, the dentition being formulated thus: d. i., $\frac{3-3}{1-1}$; d. m., $\frac{3-3}{3-3}$; m., $\frac{1-1}{1-1}$ = 24. At this stage the germ of p. 3 is visible underneath d. m. 3, but still buried in the substance of the jaw. Next d. m. 2 is shed, and m. 2 is acquired; while d. m. 3 is shed, and replaced by p. 3; soon after which p. 3 is pushed out simultaneously with the development of m. 3. From this it is evident that individuals may have the same number of molars, and yet none of them may possess homologous sets. This shows the necessity of indicating whether the molars are deciduous premolars or true molars. As the animal grows older d. m. 4 is shed, and next m. 1. Old individuals may, then, have apparently the same molar dentition as very young individuals, the difference being that the molars belong to different portions of the typical dentition. Thus a young and an old animal may have a dentition representable by the first formula above as regards molars; in the former those molars are d. m. 2 and d. m. 3, while in the latter they are m. 2 and m. 3. It will be observed that normally the teeth come and go in a definite order.

The lips are generally fleshy, and highly vascular; in most cases they are naked, but in a few are clothed with hair. This structure is admirably adapted to the important function which the lips are known to perform, of transferring the tender foetus from the vagina to the marsupial pouch.

The alimentary canal presents many modifications. Generally the œsophagus is smooth or disposed in fine longitudinal plaits; but in the Virginian opossum there are many transverse folds, like those of the *Felidæ*, but relatively larger. This structure has not been observed in any other marsupial genera, not even in those of most carnivorous habits. The stomach is either simple, as in the *Sarcophaga*, *Entomophaga*, and most *Carpophaga*, or provided with a cardiac glandular apparatus, as in *Phascolarctos* and *Phascolomys*, or complicated by sacculi, as in *Poephaga*. The cardiac extremity does not present modifications corresponding with the nature of the food and dentition, being essentially the same in *Dasyurus*, which is carnivorous; in *Perameles*, which is insectivorous; and in *Phalanger*, which feeds on leaves. The sacculated stomach of the kangaroo is the extreme modification presented by the order. It resembles the colon of man in structure, mode of disposal in the abdomen, and in its longitudinal extent. In a specimen of a full-grown female, the whole length of the stomach, measured along the curvatures, was 3 ft. 6 in., or equal to the length of the animal itself from vent to muzzle. It is described by Professor Owen as consisting of a left, a middle, and a right, or pyloric division. "The left extremity of the stomach is bifid, and terminates in two round cul-de-sacs. The sacculi of the stomach are produced, like those of the colon, by three narrow longitudinal bands of muscular fibres, which gradually disappear, together with the sacculi at the pyloric division. One of the longitudinal bands runs along the greater curvature at the line of attachment of the gastro-colic omentum; the others commence at the base of the left terminal pouches, and run, one along the anterior, the other along the posterior side of the stomach; the interspace between these bands, forming the lesser curvature of the stomach, is not sacculated. The largest of the two terminal sacculi is lined with an insulated patch of vascular mucous membrane, which is continued for the extent of five inches into the cardiac cavity; the thick epithelium is continued from the œsophagus in one direction into the nearest and smallest sacculus, and extends in a sharp-pointed form for a considerable distance in the opposite direction into a series of sacculi in the middle compartment of the stomach; the epithelium is quite smooth. The vascular mucous surface recommences by a point at the great curvature near the beginning of the middle compartment, and gradually expands until it forms the lining of the whole inner surface of the right half of the stomach. Three rows of clusters of mucous follicles are developed in the mucous membrane of the pyloric half of the middle compartment; they are placed parallel with the longitudinal muscular bands. About fifteen patches are situated along the greater curvature, and there are nine in each of the anterior and posterior rows. These glandular patches disappear altogether in the pyloric compartment of the stomach, where the lining membrane is thickened and finally corrugated, but immediately beyond the pylorus there is a circular mucous gland three-quarters of an inch broad; the non-sacculated pyloric division of the stomach was five inches in length." The specimen belonged to *Macropus major;* but in the smaller species there is less complexity, and the third longitudinal band is obsolete in some. In the large kangaroo there are two folds which together form a canal similar to what is found in the stomachs of placental ruminants. In the kangaroo it probably has some relation to a ruminating function, since this creature has been seen to compress its abdominal muscles, regurgitate food into the mouth with a concomitant bowing of the head, and chew the cud. The act is, however, not performed with anything like the regularity prevalent in true ruminants, and takes place in the erect, not in the recumbent, position. Although the stomach bears no constant relation to the kind of food in its modifications, yet such correlation is eminently displayed in the cæcum coli. In the sarcophagous marsupials the cæcum is entirely wanting, and the intestinal canal is short and wide. In the entomophagous tribe the cæcum is of moderate size, and the intestinal canal is relatively longer than in the foregoing group, as well as more complicated, being divisible into small and large intestines. In the carpophagous species the cæcum is of extraordinary length, being in some twice the length of the body. In the koala, which is strictly a vegetable feeder, this part of the canal is three times the length of the body, and its inner secreting membrane is augmented by a dozen longitudinal folds. In the species which have sacculated stomachs the cæcum is relatively shorter than in those of the simple-stomached group, which have corresponding habits and diet. In the zoophagous marsupials the intestinal canal is suspended from the commencement of the duodenum, like that of carnivorous reptiles. The annexed table indicates the relative lengths of the body and parts of the alimentary canal in a few species of the different marsupial families:—

	Body from snout to vent.		Intestinal canal with cæcum.		Small Intestines.		Large Intestines.		Cæcum.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Thylacinus Harrisii .	3	4	9	8						
Phasgogale flavipes . .	0	5	0	14						
Dasyurus macrurus .	1	4	5	0						
Perameles nasuta . .	1	4	3	5	2	5	0	9	0	3
Didelphys Philander .	0	9	3	5	1	11	1	2¼	0	4
Petaurus pygmæus . .	0	2½	0	6¾	0	5	0	0¾	0	1
Phalangista vulpina .	1	8	24	10	11	0	9	0	4	10
Phascolarctos fuscus .	1	11	24	0	7	8	10	. 5	6	5
Hypsiprymnus setosus.	1	0	5	0	2	5	2	6	0	2
Macropus major . . .	3	3	32	0	22	0	9	0	1	8
Phascolomys Vombatus	2	6	25	6	11	3	14	2	0	1

The liver is many-lobed in all marsupials. It is relatively largest in the wombat and dasyure, and smallest in the kangaroo. The gall is large in all marsupials.

The heart presents no outward feature that calls for notice. Internally it is characterised by the absence of the fossa ovalis and the foramen ovale, structures which have relation in placental mammals to the intercommunication of the right and left auricles during the fœtal condition. There is a similar communication in the fœtal kangaroo, but the fissure is subsequently completely obliterated.

The epiglottis is very large in all marsupials, and generally has an emarginate apex. In *Didelphys opossum* it is entire ; in the *Phalangers*, broad, short, and bifid ; it is also short and broad in *Perameles* and *Phasgogale*, and attached by the sides to the apices of the arytenoid cartilages. The vocal chords are slight folds of membrane not capable of being stretched, and the ligaments are wanting in the phalanger and kangaroo. In the opossum there is a lower ligament and a ventricle, and their voice is a squeak and a purr. The wombat purrs ; the *Dasyurus ursinus* growls or whines ; the thylacine makes a short guttural note ; but most of the marsupials have no voice.

(Owen, *On the Anatomy of Vertebrates*, vols. ii. and iii.)

MELANIADÆ [E. C. vol. iii. col. 754]. In the E. C. the remarks appertaining to this family are dispersed under the names of the principal genera, *Melania* and *Melanopsis*. About a generation back it numbered less than 100 species, living and extinct ; but at the present time the figures are running so high and increasing so fast that some naturalists complain that these genera, especially *Melania*, are becoming too unwieldy, and that great difficulty is experienced in coining new specific names. This has led to attempts to eliminate all groups which can possibly be defined, and raising these to the rank of genera ; and hence several new generic names have been introduced to science during the last few years. It remains for future inquirers to ascertain what these names are worth, and whether the numerical abundance of a genus can validly form the principal argument for splitting up such a genus into smaller groups, and raising them to generic distinction. In wading through the recent literature of the subject, which extends over several hundreds of pages, one feels amazed at how large a proportion is devoted to the simple description of shells, and how few words are expended in discussing what relation and function the characters have. In a truly natural series of definitions a student ought to be able to infer from a given set of characters what are the principal physiological features, general habits, and other biological details ; but can the most erudite conchologist say what is the signification of the notch in *Lithasia*, or the callous columella in *Anculosa*, independently of their value as distinctive marks ? There is a great lack of that knowledge and high philosophy which enables the student to determine in many cases what characters are analogous, what are homologous, which characters are subordinate, and the relation these points have to the life or history of the species. Dr. Lea defends the establishment of the genera to which we shall presently allude against those who object that the soft parts are unknown, in the following words :—" But there is no validity in this objection, from the fact that, in the present condition of the science of malacology, we are becoming acquainted with a vast number of new and interesting forms, without the hope at present of seeing the organic portion of the animals. These may at some future time, and no doubt will, be examined and carefully described by zoologists who may dwell near the waters where these numerous and highly developed species reside. Until this task takes place we can only group them upon the characters which are presented by their outward hard portions which are accessible to us now." He then refers to the genera and sub-genera proposed by European zoologists in this family, and shows that in most instances these are heterogeneous in composition, or, as he phrases it, " they have mixed them up in a manner so as to make great confusion." He supports his statement by reference to the labours of Swainson, Gray, Adams, Reeve, and Chenu. We suspect his strictures are well founded, and we also suspect that they will apply equally to his own groups ; better would it be to let confusion alone, than to make confusion worse confounded. In making these remarks we do not wish so much to reprobate Dr. Lea as to convey our conviction that no amount of closet work or museum study will enable one to arrive at a correct classification, and that our knowledge of the great family of *Melaniadæ*, and, indeed, of *Mollusca* generally, would be far more advanced if there was less describing, but more field-observing and anatomising. Most of the new genera are probably only temporary makeshifts, which will be abolished as soon as a knowledge of functions permit of their being discarded as convenient groups into which to sort the species. Even when the animal is noticed we find little more than description, and a heaping together of characters, but little attention being given as to what the characters mean or indicate. We will illustrate these remarks by reference to Dr. Stimpson's researches on two North American Melanians, the *Melania virginica*, Say., and the *Mudalia dissimilis* of Haldeman, both of which are living in the Potomac river. In Tryon's elaborate synonymic lists, the former has more than a dozen synonyms, the priority being given to *Goniobasis virginica* ; while the latter has upwards of 30 synonyms assigned to it, of which the priority is given to *Anculosa carinata*. The animals of these two species are very similar, and Stimpson states they must be placed in the same genus.

The snout is large and long, slightly tapers, and projects much beyond the anterior margin of the foot. It can be retracted or extended, and moved about in all directions ; and so actively are these snouts used for probing the mud, that a group of these creatures feeding on the margin of the river remind one of a herd of pigs routing about for food in muck. When contracted, the snout is transversely wrinkled, but smooth when stretched out. Its general outline is oval, and it terminates in a disk of the same shape, in which the mouth is indicated by a longitudinal slit extending from the centre to the posterior margin. The teeth are arranged in seven rows on the tænio-glossate plan, or 3. 1. 3. The central or rhachidian plate is broader than long, rotund behind, but sinuated in front ; the next plates on either side are rhomboidal in outline, with a produced angle at the outer edge of the posterior margin ; the next pair are like the outermost two, but with fewer denticles. The tentacles are of moderate size, and taper to a more or less sharp point ; and the eyes, which are black and small, are situated on slight protuberances at their outer bases. The foot is short, thick, truncated in front, rounded behind, and is generally much shorter than the shell. The operculum is horny, sub-spiral, few whorled, and is borne on a conspicuous operculigerous lobe. In adult specimens the apex is frequently broken off, which usually leads to an elongation of the operculum beyond the foot, somewhat as occurs in *Fusus*. On the right side an impressed line runs from the pallial cavity, or faces the right tentacle, whence it curves downward to near the margin of the foot. On the right side also there is a slightly sinuated opening in the pallial cavity. The branchiæ are two in number, situated on the inner surface of the mantle, and of unequal size, the longest extending to the bottom of the pallial cavity. The principal branchia gradually taper backwardly, and is composed of about fifty triangular plates, the base of the triangle being somewhat less than the height. The other branchia lies parallel to the principal one, but is reduced to a simple midrib without laminæ. The sexes are distinct, but the fact is not ascertainable without some difficulty, since there are no external generative organs, and the internal organs are so similar that they cannot be distinguished even when dissection is resorted to. By employing the microscope, however, it is observable that the contents of the organs consist of ova only in some individuals, and of spermatozoa only in others. On further examination it may be noticed that some individuals have a deep pit on the impressed line above mentioned, at a point midway between the tentacle and operculigerous lobe, while in others it is absent. This sinus or pit occurs in the females only, and is probably connected either with fecundation or the deposition of eggs ; at any rate, it is a sexual character. The absence of intromittent organs is also a feature found in the sessile ctenobranchiate *Vermeti* ; and hence Stimpson proposes to place the American Melanians, and possibly the Old World species also, along with the *Vermetidæ* in a distinct tribe, to be termed *Anandria*. The observations made by Dr. Stimpson are very important, but they seem to be too few to give adequate support to his generalization. He reviews the general conclusions to which former authors have been led respecting this group, that of the American Melanians. In the 'Iconographic Encyclopædia,' published in 1851, is an article by Professor Haldeman, in which the *Melaniadæ* are characterised by having a simple mantle without fringe or siphon, a head ending in a short snout, and by their vegetable diet. It is considered to include *Melania, Littorina, Planaxis, Eulima, Paludina, Amnicola, Valvata, Ampullaria, Leptoxis, Melanopsis, Io,* and perhaps *Scalaria*, which is a very good mixture, but certainly not a natural family. It is based upon the edge of the mantle being plain, while those species which have that edge scolloped are placed in the next family, the *Cerithiidæ*. The character is, however, one of slight importance, since in the same species every gradation may be found between a plain mantle edge and one in which the branchial siphon is margined with complicated fringes. One of Deshayes' characters of the genus *Melania* is that its mantle has festooned edges, so that Haldeman ought to place the species of *Melania* which have that character amongst the *Cerithiidæ*.

Dr. Lea rearranges the American *Melaniadæ* into the following ten genera, which he shortly distinguishes in the way indicated. In *Melania* the aperture of the shell is regularly loop-like. In *Amnicola* it is round, without part of the edge being thickened; in *Anculosa* it is also round, but the columella is callous; in *Goniobasis* it is usually sub-rhomboidal, sub-angular at the base, and not canaliculated; in *Trypanostoma* it is auger-shaped, and the outer lip is expanded; in *Eurycœlon* it is ear-shaped, and there is a callus on the columella above; in *Strephobasis* it is squarish, and the base has a retrorse callus; in *Lithasia* there is a callus on the columella above and below, and a notch at the base; in *Schizostoma* there is a cut at the upper part of the outer lip; in *Meseschiza* there is a cut at the middle part of the outer lip; and in *Io* there is a channel or spout at the base. The characters, it will be seen, are drawn from the shell only, and in the diagnoses of the species it is very rare indeed that any allusion is made to the animal. In almost every genus we find species, as defined by Dr. Lea, which do not conform to the principal character assigned to it, but this in itself is no valid objection to the genera themselves, except as indicating that there is a difficulty in precisely defining them. Thus *Amnicola Currieriana* has a constricted half-moon shaped aperture, and a columella which is so expanded and thickened as to cover the umbilicus. In some specimens the aperture approaches in character to that of *Neritina*. In *Anculosa turbinata* the aperture is anything but round, or even regular; Dr. Lea himself describes it as ovate, but it comes nearer to what we should call auriculate. So again in *Goniobasis* we find many species as described and figured by Dr. Lea, in which the aperture is not rhomboidal, but elliptical. *Goniobasis cahawbensis* has an aperture which we cannot distinguish from those of some true *Melaniæ*. It is not sub-rhomboidal, and it is not sub-angular at the base, so that the want of a channelled lip is the only feature in which it agrees with the definition. *G. lepida* is another species which has a beautifully regular elliptical aperture. *G. virgulata* has a canaliculate margin. The shape of the aperture in *Goniobasis* is so variable that no suitable term can designate it; but the differences mainly consist in the degree of curvature of the outer lip and the flexuosity of the inner lip. We might give instances from all the other genera; but this course is unnecessary.

In 1862 Dr. Lewis described the soft parts of *Melania subularis* (Lea) and *M. exilis* (Haldeman). He distinguishes the former by having a fold or sinus on the side of the foot and neck, while in the latter it is wanting. In Tryon's lists *M. exilis* stands as *Goniobasis semicarinata*, and the other species as *Pleurocera subulare*. One, therefore, belongs to the *Goniobasic* section; the other to the *Trypanostomoid* section. Soon after Dr. Lewis had made his first observations he arrived at a higher generalization, which was that Dr. Lea's views as to the propriety of dividing the American *Melaniadæ* was correct; that Dr. Lewis had found that the soft parts confirmed the conclusion which had been drawn from the shell. Dr. Lewis believes that the sinus of *Melania subularis* will be found in all the species of *Trypanostoma* or *Pleurocera*, and the granular sides of *M. exilis* in all species of *Goniobasis*. Hence the character has acquired increased importance; at first it is regarded as of specific value next of generic value, and from the way in which the facts are put, one is strongly inclined to suspect that the next step would be to make it of sectional value. There can, however, be little doubt that the sinus is simply a sexual distinction, so that all this elaborate classification tumbles down like a house of cards. What better illustration could we give of the importance of thoroughly mastering the plan of organization, and of ascertaining what relations the descriptive characters have to that plan before such characters are employed for purposes of classification and definition? Perhaps every system ought to be considered as provisional, and not a reliable guide, which is not founded on the broad basis we have indicated.

In Mr. Gill's arrangement the *Melaniadæ* forms the first family of *Tænioglossu*, and is succeeded by *Amnicolidæ* and *Viviparidæ*, the grouping being confined to American species. Its place in the scheme will be gathered from the following table of the American families of *Tænioglossa*:—

1. Rostrum moderately produced, and entire or simply notched.
    a. Foot not produced beyond head; branchiæ uniserial.
        * Lateral jaws present; aperture of shell acuminate behind; generally channelled at front; size moderate. *Melaniidæ.*
        ** Lateral jaws obsolete; aperture of shell subcircular, broadly rounded at front; size very small. *Amnicolidæ.*
    β. Foot produced considerably beyond the head; branchiæ triserial. . . . . *Viviparidæ.*
2. Rostrum produced, extending into two much-elongated subulate lobes . . . . . *Ampullariidæ.*
    A.A. Gills pinnate, plumose and exsertile forwards *Valvatidiæ.*

As thus defined, the family does not include *Pirena*, Lam.; *Melanatria*, Bow.; *Melatoma*, Sw.; *Melanopsis*, Lam.; *Vibex*, Oken; and *Hemisinus*, Sw. These last are considered to form a distinct family, characterised by the foot projecting beyond the head, and by the notch in the aperture of the shell, which Gill proposes to name *Melanopidæ*. *Melanopsis princeps*, Lea, and *M. acicularis*, Férussac, are marked by an absence of a posterior sinus in the outer lip, and are raised to a genus, named *Faunopsis*. The same author considers that the American *Melaniidæ* have no fringed mantle, and that these constitute a distinct sub-family, *Ceriphasiinæ*, from the species of the Old World.

Mr. Haldeman also recognises that the American *Melaniadæ* are distinct from those of the Old World. The two groups he regards as two families, and mentions as the principal distinctive point that in the American group the mantle is simple, while in the Old World group it is festooned. The American group he terms *Strepomatidæ*; while the Old World group he considers is a sub-family, the *Melaniana*, in the family *Cerithiidæ*. Dr. P. P. Carpenter places the Old World and the American groups together, and remarks that both have a fringed mantle. Stimpson thus criticises these conclusions:—"I trust that it is unnecessary to reiterate here that the character of the margin of the mantle, whether fimbriated or not fimbriated, though made a family or sub-family character by Haldeman and Gill respectively, is of the slightest possible importance in comparison with others easily discoverable upon patient observation. That the Old World Melanians are distinct as a sub-family from the American forms I do not deny. But the truly important distinction consists in this: the Old World species are ovo-viviparous like *Paludina* (*Viviparus*), while the American species are oviparous. Woodward, H. and A. Adams, and Carpenter, all state that the species of the *Melaniadæ* are sometimes viviparous, but do not attempt to establish a distinction on this account between the American and Old World species, nor do they inform us in what geographical area the viviparity has been observed. I am inclined to consider the Old World group as ovo-viviparous, from having found it to be the case in all of the species of that group accessible to me, while all the observations which have been made upon the American species lead to prove them to be oviparous."

In Tryon's synonymic list he adopts the name *Strepomatidæ* as proposed by Haldeman. His synopsis of the generic groups runs thus:—

A. Aperture produced into a more or less obvious canal in front . . . . *Trypanostomoid Section.*
    Genus 1. Shell fusiform, inflated, spire and canal produced.
        Columella without deposit of nacre . . *Io*, Lea.

Sub-genus. Shell conical or oval, canal not so much produced . . . . . . *Pleurocera*, Raf.

Genus 2. Shell oval or turbiniform, or fusiform, with a revolving row of nodules on the periphery; canal short. Columella callously thickened above and below. *Angitrema*, Hald.

Sub-genus. Shell oval or oblong, smaller, either smooth or adorned with nodules around the upper portion of the body. Whorl. *Lithasia*, Hald. Canal retrorse. *Strephobasis*, Lea.

B. Aperture nearly angulated in front, with no canal, and the columella perfectly plain, not twisted, frequently callously thickened above . . . *Goniobasic Section.*

Genus 3. Shell heavy, oval, oblong, or turreted. *Goniobasis*, Lea.

Genus 4. Aperture with a sutural pleurotomose slit above. *Schizostoma*, Lea.

C. Aperture entire and rounded in front.

Genus 5. Shell oval, heavy, columella callously thickened above. . . . . . *Anculosa*, Say.

In this arrangement all the American species formerly assigned to *Melania* are sorted under headings, so that this genus in the restricted sense is confined to the Old World. *Amnicola* also is excluded, in which respect Tryon agrees with most malacologists, who consider that this genus really belongs to the *Rissoidæ*. The genera *Eurycælon* and *Meseschiza*, which have been formed by Lea since the above synopsis was published, are subsequently placed by Tryon in the Goniobasic section. He also gives a synopsis of the species, which we subjoin, with full lists of synonyms and references, for which we refer the reader to the original papers and volume cited at the end of this article.

Io, Lea, 1831 (5 species).

A. Shell smooth, or only slightly tuberculate. I. fluviatilis, Say; I. inermis, Anthony.

B. Shell spinose. I. spinosa, Lea; I. brevis, Anthony; I. turrita, Anthony.

Pleurocera, Rafinesque, 1819 (89 species).

A. Tuberculate. P. alveare, Conrad; P. Foremani, Lea; P. undulatum, Say; P. excuratum, Conrad; P. moniliferum, Lea; P. nobile, Lea; P. robustum, Lea.

B. Sulcate. P. canaliculatum, Say; P. filum, Lea; P. ponderosum, Anthony; P. olivaceum, Lea; P. Troostii, Lea; P. moriforme, Lea; P. Pybasii, Lea; P. Showalterii, Lea.

C. Angulate, striate below the periphery. P. Thorntonii, Lea; P. trivittatum, Lea; P. infrafasciatum, Anthony; P. fastigiatum, Anthony; P. Postellii, Lea; P. incurvum, Lea; P. alabamense, Lea; P. florencense, Lea; P. canalitium, Lea; P. Clarkii, Lea; P. Anthonyi, Lea; P. prasinatum, Conrad; P. tortum, Lea; P. dignum, Lea.

D. Carinate and striate. P. unciale, Haldeman; P. subulare, Lea; P. intensum, Lea; P. subulæforme, Lea; P. Henryanum, Lea; P. Lewisii, Lea; P. annuliferum, Conrad; P. Brumbyi, Lea; P. Currierianum, Lea.

E. Plicate. P. sycamorense, Lea; P. plicatum, Tryon.

F. Smooth and angulate. P. elevatum, Say; P. gradatum, Anthony; P. aratum, Lea; P. lativittatum, Lea; P. strictum, Lea; P. modestum, Lea; P. Leaii, Tryon; P. Tuomeyi, Lea; P. gracile, Lea; P. Spillmanii, Lea; P. planogyrum, Lea; P. pyrenellum, Conrad; P. regulare, Lea; P. validum, Anthony.

G. Smooth species; not angulated. P. glandulum, Anthony; P. Christyi, Lea; P. labiatum, Lea; P. pallidum, Lea; P. neglectum, Anthony; P. vestitum, Conrad; P. strigosum, Lea; P. lugubre, Lea; P. picta, Lea; P. tenebrocinctum, Anthony; P. Vanuxemii, Lea; P. chakasahaense, Lea; P. Knoxense, Lea; P. altipetum, Lea; ocoeense, Lea; P. hastatum, Anthony; P. Lyonii, Lea; P. viridulum, Anthony; P. sugillatum, Reeve; P. striatum, Lea; P. Knoxvillense, Lea; P. Whitei, Lea; P. attenuatum, Lea; P. Estabrookii, Lea; P. modestum, Lea; P. luteum, Lea; P. curvatum, Lea; P. simplex, Lea; P. bivittatum, Lea; P. turgidum, Lea; P. minor, Lea; P. pumilum, Lea; P. opaca, Lea; P. trochulus, Lea.

Angitrema, Haldeman, 1841 (12 species).

A. Body whorl, with a coronal of tubercles. A. geniculata, Haldeman; A. salebrosa, Conrad; A. subglobosa, Lea; A. Tuomeyi, Lea.

B. Body whorl, encircled above the aperture by two rows of tubercles, of which the inferior one is most prominent. A. Jayana, Lea.

C. Body whorl, with a central row of tubercles. A rota, Reeve; A. armigera, Say; A. Duttoniana, Lea; A. stygia, Say; A. funiculata, Reeve; A. luna, Conrad; A. verrucosa, Rafinesque.

Lithasia, Haldeman, 1840 (15 species).

A. Shell large, oval, inflated. L. fuliginosa, Lea; L. florentiana, Lea; L. venusta, Lea; L. dilatata, Lea; L. imperialis, Lea.

B. Shell small, compact, oval, elliptical. L. vittata, Lea; Showalterii, Lea; L. nuclea, Lea; L. nucleola, Anthony; L. undosa, Anthony; L. obovata, Say; L. consanguinea, Anthony.

C. Shell subcylindrical. L. brevis, Lea; L. fusiformis, Lea; L. Downiei, Lea.

Strephobasis, Lea, 1861 (8 species).

A. Shell ovate, conical. S. curta, Haldeman; S. pumila, Lea; S. carinata, Lea.

B. Shell cylindrical. S. olivaria, Lea; S. plena, Lea; S. cornea, Lea; S. corpulenta, Anthony; S. bitæniata, Conrad.

Goniobasis, Lea, 1862 (263 species).

A. Shell spirally ridged. G. proscissa, Anthony.

B. Shell tuberculate or nodulous. G. varians, Lea; G. Hydeii, Conrad; G. decorata, Anthony; G. cælatura, Conrad; G. Stewardsoniana, Lea; G. flavescens, Lea; G. occata, Hinds; G. catenaria, Say; G. catenoides, Lea; G. etowahensis, Lea; G. Hallenbeckii, Lea; G. Boykiniana, Lea; G. Bentoniensis, Lea; G. papillosa, Lea; G. Couperii, Lea; G. inclinans, Lea; G. Postellii, Lea; G. arachnoidea, Anthony; G. Conradi, Brot; G. carinifera, Lamarck; G. abbreviata, Anthony; G. vesicula, Lea.

C. Shell plicate. G. obesa, Anthony; G. blanda, Lea; G. aequalis, Haldeman; G. semigradata, Reeve; G. carinocostata, Lea; G. Lecontiana, Lea; G. cadus, Lea; G. obtusa, Lea; G. amœna, Lea; G. Tuomeyi, Lea; G. interveniens, Lea; G. olivella, Lea; G. interrupta, Haldeman; G. crispa, Lea; G. formosa, Conrad; G. mediocris, Lea; G. Duttonii, Lea; G. laqueata, Say; G. Pybasii, Lea; G. induta, Lea; G. versipellis, Anthony; G. gracilis, Lea; G. paucicosta, Anthony; G. tenebrosa, Lea; G. coracina, Anthony; G. intersita, Haldeman; G. columella, Lea; G. blanda, Lea (a different species from the one so named higher up; this is the oldest); G. nitens, Lea; G. mutata, Brot; G. suturalis, Haldeman; G. mutabilis, Lea; G. viennaensis, Lea; G. Curreyana, Lea; G. costifera, Haldeman; G. Deshayesiana, Lea; G. abbevillensis, Lea; G. Doolyensis, Lea; G. inconstans, Lea; G. continens, Lea; G. viridecata, Lea; G. purpurella, Lea; G. semicostata, Conrad; G. dislocata, Ravenel; G. Lindsleyi, Lea; G. paupercula, Lea; G. corneola, Anthony; G. nassula, Conrad; G. perstriata, Lea; G. rugosa, Lea; G. costulata, Lea; G. cinerella, Lea; G. caliginosa, Lea; G. nodulosa, Lea; G. difficilis, Lea; G. sparus, Lea; G. Thorntonii, Lea; G. cancellata, Say; G. circinata, Lea; G. athleta, Anthony; G. curvicostata, Anthony; G. striatula, Lea; G. tripartita, Reeve; G. decora, Lea; G. crebricostata, Lea; G. comma, Conrad; G. acuta, Lea; G. subcylindracea, Lea; G. baculum, Anthony; G. concinna, Lea; G. eliminatum, Anthony; G. teres, Lea; G. gracillima, Anthony; G. Clarkii, Lea; G. De Campii, Lea; G. abbreviata, Anthony; G. plicifera, Lea; G. silicula, Gould; G. nigrina, Lea; G. rubiginosa, Lea; G. Bairdiana, Lea.

D. Shell angulate. G. trochiformis, Conrad; G. cristata, Anthony; G. cruda, Lea; G. Whitei, Lea; G. expansa, Lea; G. casta, Anthony; G. rhombica, Anthony; G. angulata, Anthony; G. Bridgesiana, Lea; G. cubicoides, Anthony; G. Spillmanii, Lea; G. pallidula, Anthony; G. vicina, Anthony; G. Spartenburgensis, Lea; G. modesta, Lea.

E. Whorls very strongly carinated. G. pagodiformis, Anthony; G. Gerhardtii, Lea; G. acutocarinata, Lea.

F. Body whorl, bi-multi-angulated. G. tabulata, Anthony; G. Catawbæa, Haldeman; G. vittata, Anthony; G. subangulata, Anthony; G. symmetrica, Haldeman; G. iota, Anthony; G. nigrocincta, Anthony; G. tecta, Anthony; G. hybrida, Anthony; G. fuscocincta, Anthony; G. congesta, Conrad.

G. Short, clavate, smooth, species. G. auriculæformis, Lea; G. Nickliniana, Lea; G. aterina, Lea; G. Binneyana, Lea; G. ebenum, Lea; G. Vauxiana, Lea; G. larvæformis, Lea; G. auricoma, Lea; G. glabra, Lea; G. graminea, Haldeman; G. gibbosa, Lea; G. cognata, Anthony; G. Georgiana, Lea; G. abrupta, Lea; G. depygis, Say; G. livescens, Menke; G. simplex, Say; G. potosiensis, Lea; G. torta, Lea; G. Saffordi, Lea; G.

virens, Anthony; G. Newberryi, Lea; G. bulbosa, Gould; G. lithasioides, Lea; G. infantula, Lea; G. louisvillensis, Lea.

H. Smooth, elevated species. G. pulchella, Anthony; G. cinerea, Lea; G. gracilior, Anthony; G. etowahensis, Lea (this name has also been given to a species in group B., which is the oldest); G. translucens, Anthony; G. ovoidea, Lea; G. grata, Anthony; G. quadricincta, Lea; G. flava, Lea; G. tenebrovittata, Lea; G. tenera, Anthony; G. Elliottii, Lea; G. pallescens, Lea; G. parva, Lea; G. Anthonyi, Lea; G. cahawbensis, Lea; G. Gabbiana, Lea; G. sordida, Lea; G. clavæformis, Lea; G. castanea, Lea; G. adusta, Anthony; G. furva, Lea; G. dubiosa, Lea; G. lævigata, Lea; G. interlineata, Anthony; G. ohioensis, Lea; G. brevispira, Anthony; G. semicarinata, Say; G. Haldemani, Tryon; G. curvilabris, Anthony; G. informis, Lea; G. vittatella, Lea; G. Alexandrensis, Lea; G. Haleiana, Lea; G. rubella, Lea; G. spinella, Lea; G. Draytonii, Lea; G. proxima, Say.

I. Striate species, spire elevated. G. virginica, Gmelin; G. sulcosa, Lea; G. Buddii, Lea; G. Troostiana, Lea; G. latitans, Anthony; G. porrecta, Lea; G. sculptilis, Lea; G. crenatella, Lea.

J. Heavy, pupæform, or cylindrical species. G. cylindracea, Conrad; G. pupoidea, Anthony; G. litta, Lea; G. fallax, Lea; G. inosculata, Lea; G. alabamensis, Lea; G. rara, Lea; G. punicea, Lea; G. pudica, Lea; G. fabalis, Lea; G. shelbyensis, Lea; G. fumea, Lea; G. æqua, Lea; G. solidula, Lea; G. olivula, Lea; G. fascinans, Lea; G. Showalterii, Lea; G. clausa, Lea; G. crepera, Lea; G. abscida, Anthony; G. Vanuxemiana, Lea; G. coosasensis, Lea; G. rubicunda, Lea; G. Haysiana, Lea; G. arctata, Lea; G. ampla, Lea; G. mellea, Lea; G. ambusta, Lea; G. læta, Jay; G. harpa, Lea; G. oliva, Lea; G. proteus, Lea; G. grisea, Anthony; G. culta, Lea; G. luteola, Lea; G. gravida, Anthony; G. germana, Anthony; G. variata, Lea; G. ovalis, Lea; G. virgulata, Lea; G. clara, Anthony; G. inflata, Haldeman; G. fusiformis, Lea; G. bellula, Lea; G. calculoides, Lea; G. basalis, Lea; G. Lewisii, Lea; G. ellipsoides, Lea; G. elliptica, Lea; G. bullula, Lea; G. excavata, Anthony; G. purpurea, Lea; G. quadrivittata, Lea; G. propria, Lea; G. negata, Lea; G. impressa, Lea; G. pergrata, Lea; G. capillaris, Lea.

Eurycœlon, Lea, 1864 (8 species).

E. umbonata, Lea; E. Midas, Lea; E. gratiosa, Lea; E. lachryma, Anthony; E. gibberosa, Lea; E. nubila, Lea; E. Anthonyi, Budd; E. crassa, Haldeman; E. turbinata, Lea.

Meseschiza, Lea, 1864 (1 species).

M. Grosvenori, Lea.

Schizostoma, Lea, 1842 (26 species).

The species are thus arranged by Tryon, who points out that the genus is divisible into two groups; the opposite species in the table are very nearly similar, if the nature of the fissure be not taken into account.

Fissure direct, narrow, and deep.	Fissure oblique, short, and wide.
1. Shell striate or ridged.	
a. Shell conical, spire lengthened, sharply carinate.	
1. S. cariniferum, Anthony.	15. S. pagodum, Lea.
2. S. castaneum, Lea.	16. S. pyramidatum, Shutt.
	17. S. Wetumpkaense, Lea.
b. Shell conic-cylindrical, spire obtuse, not carinate.	
3. S. ovoideum, Shutt.	18. S. alabamense, Lea.
	19. S. Anthonyi, Lea.
4. S. excisum.	20. S. babylonicum, Lea.
c. Shell globosely-ovate, spire moderate.	
5. S. pumilum, Lea.	21. S. Buddii, Lea.
2. Shell smooth.	
d. Shell elliptic.	
6. S. ellipticum, Anthony.	
7. S. laciniatum, Lea.	
e. Shell quadrately cylindrical.	
8. S. amplum, Anthony.	22. S. denissum, Anthony.
9. S. nuculum, Anthony.	
	23. S. constrictum, Lea.
10. S. cylindraceum, Mighels.	24. S. salebrosum, Anthony.
f. Shell ovate, whorls obliquely flattened, spire obtuse.	
11. S. bulbosum, Anthony.	25. S. glandulum, Lea.
	26. S. incisum, Lea.
12. S. curtum, Mighels.	
13. S. glans, Lea.	
g. Shell globose.	
14. S. sphæricum, Anthony.	

Anculosa, Say, 1821 (28 species).

A. Nodulous species. A. plicata, Conrad.

B. Sulcate. A. Showalterii, Lea; A. canalifera, Lea.

C. Striate. A. littorina, Haldeman; A. costata, Anthony; A. rubiginosa, Lea.

D. Angulated. A. carinata, Bruguière; A. dilatata, Conrad; A. corpulenta, Anthony; A. melanoides, Conrad.

E. Shell smooth, globose or flattened above. A. trilineata, Say; A. subglobosa, Say; A. prærosa, Say; A. tæniata, Gould; A. Troostiana, Lea; A. pinguis, Lea; A. pisum, Haldeman; A. contorta, Lea; A. vittata, Lea; A. planospira, Anthony; A. ampla, Anthony; A. zebra, Anthony; A. picta, Conrad; A. ornata, Anthony; A. Lewisii, Lea; A. squalida, Lea; A. humerosa, Anthony; A. ligata, Anthony.

If fully worked out, the geographical distribution of the *Melaniadæ* would present many interesting points. As regards North America, it would seem that the species there form a group distinct from the rest of the family as developed in other parts of the world, but sufficient investigation has not been made to permit of this conclusion being accepted as established. Supposing it to be a true one, the enormous profusion of species, the restriction of the group almost entirely to the eastern side of the Rocky Mountains, the limitation of some of the minor groups to certain rivers, and the close interlinking or gradation of the species into one another where most abundant as species, are facts which stand out most conspicuously. This collocation of phenomena points to the hypothesis that the American species, and possibly sections of the family, have been developed but recently in that country; but we require to know more about the extinct forms of the United States, as also about the species which are entombed in the delta formations of the Coosa, Mississippi, and other rivers. Meek mentions a few species of *Goniobasis* and *Melania* from the middle eocene strata of Utah, Dakotah, and the neighbouring states; but it is doubtful if they belong to these genera; at any rate, none are identified with living forms. The isolation of the American species is in marked contrast to the wide dispersal of the species and genera of the old world. For instance, *Melania amarula* is said to occur in the fresh waters of Madagascar, Mauritius, and East Indies. *M. tuberculata* occurs in Lake Nyassa, in the Lake of Tiberias, abundantly in a semifossil condition in the marl deposits on the shores of the Dead Sea, in India, in Ceylon, and, as a variety, in the Fiji Islands. At least nine species of the genus occur abundantly in New Caledonia, although in the other Pacific Islands it is to all appearance comparatively rare. In Palestine there is a slight approach to what occurs in the United States, in the case of the genus *Melanopsis*. One species, *M. prærosa*, occurs in the fossil condition, and is evidently a species of long standing. It is abundant in the living state in all the streams of Palestine, but each district has a distinct and peculiar variety. One variety, for instance, exists in the streams near Engedi and the other small watercourses which lead into the Dead Sea; another occurs in the waters of Merom and in the Lake of Galilee. Some species are also limited to very small areas; thus, *M. ammonis* is only known in the stream at Heshbon and east of Ammon; *M. costata* is very abundant in the waters of Merom, the Lake of Galilee, and in the Upper Jordan, but has never been recorded from any locality south of the entrance to the Sea of Galilee; *M. jordanica* occurs in the Lake of Galilee and in the Lower Jordan, but nowhere north of the entrance to the lake. These facts are very remarkable. He who can explain them will be able to narrate an interesting chapter in the history of molluscan life, and would render the dry descriptive lists pregnant with interest and meaning. Such a work is, however, too high for us; we cannot attain unto it.

(Tryon, *Proc. Acad. Nat. Sci. Philad.*, vol. for 1863, pp. 306—321; vol. for 1864, pp. 24—48; 92—104; vol. for 1865, pp. 19—36; Lea, *Observations on the Genus Unio, &c.*, vols. ix., x., and xi.; Stimpson, *Am. Journ. of Sci.*, 2nd series, xxxviii., pp. 41—53; Gill, *Proc. Acad. Nat. Sci. Philad.*, vol. for 1863, p.

33, et seq.; Haldeman, in same volume, pp. 273, 274; Tristram, *Proc. Zool. Soc. for* 1865, p. 541; &c.)

MELOE [E. C. vol. iii. cols. 765—766]. In the E. C. article a brief allusion is made to the discussion amongst entomologists as to the mode of development of the larva of *Meloe*, and the view is there taken that the larva is not parasitic upon bees. This subject has been investigated by M. Fabre in his peculiarly happy style, and as his researches present a clear outline of a very remarkable episode in the life of insects, a life which abounds in so many striking facts, we will follow him in his revelations as to the development and manners of two of the genera of this family, viz., *Sitaris* and *Meloe*. In many of his observations, however, he had already been forestalled by Newport.

The favourite dwelling-place of *Sitaris humeralis* is in the galleries frequented by the honey-collecting bees of the genera *Osmia* and *Anthophora*. These habitations are usually in some slope which is frequently exposed to the sunshine, such as the sides of a railway cutting, or amidst the crevices of a rocky quarry. Their contents are to all appearance remarkably heterogeneous, but, as will be seen, there is reason in it all. When one of these haunts is visited in August all seems quiet and deserted; the angles are filled with spiders' webs, in which are entangled the desiccated mummies of male individuals of *Sitaris*. If we were, however, to dig a few inches into the bank, we should find thousands of larvæ awaiting in a torpified condition, and enclosed in little cells formed of clay, their revivification in the coming spring. On continuing to give our attention to the place, we should ever and anon observe some living male of *Sitaris* creeping amongst its dead mates, ready to pounce upon the first individual of the opposite sex he can see leaving the galleries, with whom he effects a union, and almost immediately after dies. The female disappears, and subsequently lays her eggs in the galleries formed and frequented by the bees, which task done, she also expires. Occasionally, also, a little black and white dipterous insect (*Anthrax sinuata*) glides into the galleries, lays its eggs, and dies in the spider's meshes. But why should these things always happen in the vicinity of the haunt of a particular species of bee, *Anthophora pilipes?* An answer to this and many other questions which we shall have occasion to put, will be given in the sequel. Let us examine more minutely the state of the galleries in August. The bank is riddled with a multitude of circular perforations, which lead into sinuous passages connected with a series of chambers and cells. The first, or outermost set of cells, have a different appearance from those situated at a lower level. This arises from the circumstance that two kinds of bees inhabit the same spot, viz., the *Anthophora*, already mentioned, and *Osmia tricornis*. The *Anthophora* appears first on the scene, and executes all the digging and the formation of galleries. When its busy time is over, and the haunt is quiet, the *Osmia*, selecting abandoned crevices and holes, gladly occupies the apparently vacated passages, and converts them into a system of cells by means of partitions of earth. These cells are grouped without any regard to regularity, in which respect they present a marked contrast to the well executed and geometrically arranged cells of *Anthophora*. These last are formed in the substance of the bank itself, and the narrow aperture of each is closed by a thick cover which is placed over it after the egg and honey have been deposited within. These cells are carefully smoothed and polished within, and the whole arrangement affords a sufficient protection against the numerous prowling insects which enter the galleries in order to eat all the larvæ they can find. The cells of *Osmia*, which are protected by thin partitions, are easily entered by such predatory enemies; but in this genus the larvæ are able to envelope themselves in brownish and thick-walled ovoidal cocoons. If a few of these cocoons be opened some will be found to contain the larva, not of *Osmia*, but of *Anthrax*. This larva begins to twist and roll itself about at the slightest touch; so that its presence may be detected before opening the cocoon by the noise of its body rolling and striking against the inside of the cocoon. Its cephalic extremity is armed with a six-spiked battering-ram apparatus, and the dorsal aspects of the four anterior abdominal segments are armed with double rows of hooks. A further search tells us that some of the larvæ are on the point of escaping from the galleries, but in these individuals the cephalic portion is split, and from the fissure there protrudes the perfect *Anthrax sinuata*, which is quite unable of itself to cut its way through the cocoon, and to pierce through the tough clay, which can be penetrated with difficulty only, even by means of a pick-axe. This labour must be performed by the larva, which is well-organised for its task, and immediately the work is over the tools are discarded. By digging farther into the bank the cells of *Anthophora* are reached. These present various aspects. Some probably were formed in the preceding May, and contain larvæ; others, of greater age, are occupied by the perfect insect, which will pass the winter in this prison; yet others, as numerous as the foregoing, contain a parasitical hymenopterous insect, *Melecta armata*, also in the perfect state; and yet a fourth set contain a remarkable ovoid cocoon, divided into segments, provided with stigmatic protuberances, exceedingly fragile, and of such a translucent amber colour that there can be distinctly seen within it a fully developed *Sitaris humeralis*. The union of the sexes at the entrance of the galleries, and the deposition of the eggs at the entrance of the same by the females, undoubtedly has a direct relation to the occurrence of these larvæ; but how could these latter attain the position in which they are found? and how is it that the *Sitaris* is enveloped in a cocoon, seeing that cocoons are not known to be formed by any of the *Coleoptera?* Can it be that the *Sitaris* is parasitic within a chrysalis, which is itself parasitic on the larva of *Anthophora?* In such case, then, how could the *Sitaris* get inside the cell of *Anthophora*, which shows no trace whatever of having been injured or penetrated?—not a cranny nor hole can be seen in it even by the assistance of a lens. These are questions which Fabre put to himself, and, as he tells us, their solution consumed three years.

In the first year he collected a multitude of the enigmatical cocoons of the adult *Sitaris*, and observed, at his leisure, the escape of the insects therefrom, as also the subsequent union of the sexes, and deposition of eggs. The rupture of the cocoon is easily effected by a few blows with the mandibles and a few kicks with the legs. Copulation occurs immediately after the escape of the female. The early carrying out of this function is essentially necessary to the preservation of the species. After it has been effected both individuals smooth their feet and antennæ by drawing them through their mandibles, and then each goes its way. The male retires to a dark corner, languishes for two or three days, and dies. The female lays her eggs within the galleries, and dies on the spot. Hence we have an explanation of the crowds of dead males in the spiders' webs near the haunts of *Anthophora*. The adults never wander from these localities; they are never met with creeping about flowers or grasses; but all their duties are performed in the spots just noticed, and apparently nowhere else. They possess a digestive apparatus in a normal state of development, but according to Fabre not a particle of food is eaten by them as adults. The fecundated females are very particular where they lay their eggs, running about in great anxiety until they find a suitable spot. The eggs are not, as might be supposed, placed within the larva of *Anthophora*, one in each cell. In order to satisfy himself on this point, Fabre introduced a fecundated female into a large flask containing a clod of earth in which were numerous cells of *Anthophora*. On the under side of the cork was scooped a cylindrical canal, open at one end, but closed at the other, the bore of which was the same as the diameter of the galleries of *Anthophora*. In order to facilitate ingress into this canal the flask was laid in a horizontal position. The female, whose locomotion was much impeded by its heavy egg-laden body, examined every corner of its new abode, and felt everything with its feelers. After half an hour's careful search and tapping, the abdomen was thrust into the horizontal tube abovementioned, the fore part of the body projecting beyond its aperture. In this position it remained quite motionless for 36 hours, during the whole of which time it kept up a constant exclusion of eggs at the rate of one per minute. No cessation was detected in the ovi-position during the hours of watching, so that it would appear that a single individual will lay upwards of 2000 eggs. The eggs are oval in form, white in colour, and very minute in size. They are loosely cemented together, and are thrown down in an irregular heap. This great profusion of eggs, Fabre observes, implies that the offspring are liable to many sources of destruction, and that so great a number is required to secure the survival of as many as will maintain the species in sufficient abundance. Thus enlightened he sought for the eggs in the galleries of *Anthophora* in their natural position, and invariably found the small heap of white eggs within one or two inches of the external orifices of the galleries. The eggs are not protected in any way, but are left exposed to the cold of winter, and the voracious appetites of spiders, acari, and other creatures which habitually traverse these passages, and which would certainly not refrain from destroying all the eggs that came in their way. Great fecundity is necessary to counterbalance the destruction to which the eggs are liable. The eggs are hatched about a month after having been laid, that is, towards the confines of September and October. Once liberated, it might be thought the larvæ would crawl away, and disperse themselves in all directions, in order to gain access to the cells of *Anthophora*. Such is not the case. They remain on the spot amidst the broken eggshells which formerly enveloped them, although they have powerful legs. Nothing will tempt them to move. Even drawing a needle through their midst only causes a little temporary kicking and wriggling. If one is touched it draws back, endeavouring to protect itself behind the others. These larvæ, which are designated primitive larvæ, or those which are in their first stage of development, are described as being rather less than ·039 inch in length. They have a tough, leathery integument, and a shiny, blackish green colour. In shape they are convex above, flat below, and elongate, the diameter gradually increasing from the head to the hinder margin of the metathorax, and then rapidly diminishing. The head is rather longer than wide, slightly enlarged towards its base, reddish towards the mouth, and more deeply tinted towards the ocelli. The labrum forms the segment of a circle, is reddish in colour, and is fringed with a few strong short cilia. The mandibles are powerful, red, curved, sharp, and touch without crossing when not in use. The maxillary palpi are moderately long, and composed of two cylindrical, equal articulations; the outermost terminates in a short cilium. The jaws and lower lip are too indistinct for definite description. The antennæ consist of two cylindrical articulations, are slightly spaced apart, and are nearly of the same length as the palpi; the last articulation supports a long bristle three times the length of the head, and which tapers to a point almost invisible with the lens. Behind the base of each antenna are two unequal ocelli in close contiguity. The thoracic segments are co-equal in length, but gradually widen from before to behind. The prothorax is much wider than the head, but much narrower anteriorly than posteriorly. The feet are of moderate length, of considerable robustness, and terminate in a very mobile, sharp, long, and powerful claw. On the thigh of each foot is a long bristle similar to those on the antennæ, almost as long as the leg itself, and directed perpendicularly to the plane of locomotion when the animal is progressing. There are also some stout cilia on the legs. The abdomen consists of nine segments, which do not materially differ from one another in length, but are not so long as those of the thorax, and rapidly diminish in width. On the under side of the membranous connection between the eighth and ninth segments are two slightly curved, short but strong, sharp, and hard pointed processes, one on either side of the median line. By adequate means these can be made to interlock. The ninth segment carries on its outer margin two long bristles like those on the feet, and having a downward curve. Beyond this is the fleshy anal papilla. When at rest the various segments overlap, but when marching they are drawn apart, more especially those of the abdomen, and the membranous connections occupy as much space as the horny arches. At the same time the anal segment is drawn out telescopically from the eighth, as from a sheath; the anus itself is pinched out into a longer papilla; and the two points of the penultimate ring are slowly erected, then suddenly depressed so as to give a spring-like push. When ready this larva is able to make its way along the smoothest surface. For this purpose the last segment and the anal papilla are bent down at right angles with the axis of the body, and the anus is applied to the surface of support, upon which it drops a hyaline and thready fluid which glues the larva down, supported on a kind of tripod formed by the anal papilla and the two bristles of the last segment. If it should be on a glass slide, the slide may be tilted at all angles, turned upside down, and even filliped sharply with the nail without causing its fall, secured as it is by the sticky fluid. If an attempt be made to jerk it off it arches its abdomen, clutches at everything it can with its long nails, and digs the processes beneath the eighth segment downwards, then contracts the abdominal segments together, thus drawing the hindermost parts forward, when it again makes the two processes a fulcrum, and repeats these curious manœuvres. In the midst of these movements the long bristles trail along, materially impeding progress by their length and elasticity. Fabre states that Nature never allows the smallest or least organized of her organic works to be hampered with organs which are inconvenient or injurious, so that it is clear that walking on a smooth or even a rough level hard surface is not the usual habit of this creature. Its whole organization adapts it to retain a firm hold on some body which is in constant motion, and which subjects the larva to sudden shocks. But what body can it be which is so mobile, so vacillating, and so difficult to remain on, as to be specially adapted for the larval *Sitaris?* In order to solve this question he was obliged to wait till the following spring. The spring came and he used every endeavour to find out, but the enigma remained undiscovered, and he had to wait another year. The observations made in the spring were, however, not without instruction. Towards the end of April the young larvæ in the flask, hitherto motionless, and concealed in the spongy heap of broken eggs, began to run about. From their rapid and constant movements it was easy to perceive that they were in eager search for something. What could this be but food? They had retained a weak vitality for seven months, but during the whole of that time had taken no nourishment. No wonder they were spurred on by imperious hunger. And this nourishment must, it may be thought, be nothing else than the contents of the cells of *Anthophora*. Impressed with this idea Fabre offered his imprisoned larvæ the cells of *Anthophora*, some occupied by the larvæ of the bee, and others by those of *Anthrax;* some were opened, and some were left closed so as to imitate the condition of things observed in the bank in the autumn. Some of the larvæ of *Sitaris* were placed in the cells, on the flanks of the hymenopterous larvæ, and under every conceivable circumstance that would be likely to induce them to eat. Every contrivance failed. The *Sitaris* larvæ would touch nothing. Honey was tried, but as none formed or collected by this particular species of *Anthophora* could be obtained, other kinds of honey were tried, but no good result followed. All through May he searched for the cells of *Anthophora*, and at last he found a few which had been recently closed up. They were full of a blackish, fluid honey, having a most nauseous odour, on the surface of which rested a hymenopterous larva recently hatched. He withdrew the larva with every care and placed a young *Sitaris* in its place. In other cells two or more young individuals were placed on the honey; and in others the young of *Sitaris* were placed within without taking out the hymenopterous larva. Then all the cells were enclosed in a glass tube where the *Sitaris* larvæ could be watched enjoying their repast without being inconvenienced. The watching was of no avail, for no banquet took place. Those which had been placed near the mouth of the cells did not attempt to reach the honey, but did all they could to escape from the glass tube. Those which had been placed near the honey got their legs entangled with it, which only embarrassed them, causing them to fall into the fluid; and those which had been placed on the honey died in convulsions and by suffocation. "Never," cries Fabre, "did experiment ever fail so completely. Larvæ, nymphs, cells, honey, everything has been offered to you; what can you want, you plaguey little brutes?" In despair he resorted to a locality where *Anthophora* was known to be abundant, but the work of the year was over, and he was compelled to wait as patiently as his enthusiasm would allow for another twelve months. When these had elapsed his captive larvæ of *Sitaris* were again in restless commotion. Acting upon a hint derived from observations made by Newport on *Meloe*, he captured the first individual of the genus *Osmia* which he saw and thrust it into his glass flask containing *Sitaris*. In the course of a few minutes he examined the *Osmia* with a lens and discovered five larvæ of *Sitaris* adhering to the down on its thorax. This then seemed to settle the question; and it was confirmed by his placing a number of the *Sitaris* larvæ in the flowers near his windows. He repeatedly found that these larvæ attached themselves to the thorax of the down-covered *Hymenoptera*, and in several instances to that part of the body of male individuals of *Anthophora*. He hastened to repeat these observations at the galleries in the bank. At first he had misgivings as to the value of the experiments, since the first few days of his visit were cold and rainy; and no hymenopterous insects appeared on the few spring flowers which had expanded. At the entrance of the galleries he one day found some specimens of *Anthophora* in a motionless torpid state. As he took them up one after the other to examine them with a lens, he was delighted to find one or more larvæ of *Sitaris* on the thorax of each one. He went to other galleries, but the result was the same in all. He describes this as one of the happiest moments of his life, since he found that for which he had been seeking for years. The succeeding days were warm and calm; the individuals of *Anthophora* quitted their retreats in order to roam over the fields and revel amongst the flowers. He caught specimens as they flew waywardly from plant to plant, either in the neighbourhood of their birth-place, or many miles therefrom, but in very few instances did he fail to find one or more larvæ of *Sitaris* on the thorax. In localities where *Sitaris* is abundant scarcely a single *Anthophora* is without its parasite; but in districts where it is rare it is the exception for *Anthophora* to be infested with them. He further notices that on examining the galleries where the heaps of *Sitaris* larvæ were known to occur, some days after the appearance of *Anthophora* the little heaps were found to have disappeared. From this it is clear that when the individuals of *Anthophora* burst the cells and run through the galleries to fly into the air, the little parasites running eagerly about under some powerful instinctive feeling, must have buried themselves in the fur of the *Anthophoræ* just as they were about to take wing, or just as they had alighted after a flight; and having done so they cling on so firmly by the means above indicated, as will effectually prevent their easy dislodgement. They usually have a position perpendicular to the body of the *Anthophora*, being glued to a hair by the sticky fluid which they exude, and having the head directed downwards. In this position each remains motionless, never attempting to derive nutriment by gnawing the hair, nor wandering over the skin for the purpose of sucking through it the juices of the body. The parasites generally select the thorax, which is the hardest, not the thinnest, part of the bee's body, but occasionally it takes up a place on its head. As further indications that the parasites do not subsist on the substance of their hosts, it may be observed that they retain their position long after the death of the bee should they not have succeeded in transferring themselves to a more suitable place; and that their jaws are not adapted for gnawing the down. The mandibles, it is true, are sharp and curved, but they would not be adequate to eroding or bruising the down, however well they may serve for piercing. Moreover, the individuals of *Anthophora* manifest no uneasiness at their presence, nor endeavour to dislodge them. Everything tends to show that this position is temporary, and one step in the complicated manœuvres requisite for the *Sitaris* to find its way into the cells of *Anthophora.* The parasites retain their hold in spite of the rapid flight of the bees, the friction of their bodies against the walls of the galleries, and the occasional passage of the feet of the bees through the mandibles for the purpose of cleaning them. This, then, is the body so moveable, so vacillating, and so full of danger on which the *Sitaris* is organized to dwell. This body is the hair of a hymenopterous insect which executes a thousand varied motions, which now plunges headlong into its galleries, anon forces its way through the narrow corolla of a plant, and when at rest busies itself in divesting its down of the dusty particles that have clung to it. The special use of the clasping processes for embracing the hair, of the drop of tenaceous fluid for adhering more firmly in the case of a sudden downward jerk, of the long elastic bristles for anchoring the larva amongst the down, now seems to be clear. Every portion of the organism is manifestly conducive to the benefit of the species.

The parasites are, however, still far from having reached their final destination. As yet all the specimens found as parasites by Fabre were restricted to the male individuals of *Anthophora.* This restriction in the earlier spring months is explained by the circumstance that the males are liberated one month before the females, so that by the time the latter are released most of the individuals of *Sitaris* have either perished or found temporary quarters. Another remarkable circumstance is that the *Sitaris* is not found on the males of *Osmia tricornis*, which frequent the same galleries as *Anthophora*, and are freed earlier than the males of that genus. But this is apparently accounted for by the fact that the *Sitaris* larvæ do not assume their active condition until the first appearance of *Anthophora.* If, when in this state, they are placed in flasks along with almost any downy hymenopterous insect, they manifest no preference for *Anthophora*, but attach themselves to any. Although at first restricted to the males of *Anthophora pilipes*, it is essential that the parasites should be transferred to the females, since the males take no direct share in laying the eggs or in constructing the cells, such work belonging entirely to the females. There is little doubt that the transfer of the parasite takes place during the union of the sexes. Fabre conducted several experiments with a view to confirming this supposition, the result of which was to show that whenever the males were held in contact with the females the parasites almost invariably left the former and crept on to the latter. Not satisfied with this Fabre determined on endeavouring to see the transfer under natural circumstances. For this purpose he went to a locality where this species of *Anthophora* was abundant, towards the end of May. Having removed a layer of earth, he came upon a swarm of bees, which was roused into intense activity by the flood of light and heat which the sunshine poured upon it. It formed a cloud of insects some feet deep and of considerable longitudinal dimensions. From the tumultuous bosom of the cloud there issued a monotonous menacing murmur, while the eye wandered without the power of fixing itself on anything, so great was the commotion. With amazing rapidity thousands of *Anthophoræ* would alight at the same moment, and other thousands would fly off to wander amidst the flowery meadows; by-and-by these would come back, some bearing loads of honey, and others loads of mortar. Amidst all this incessant fluctuation of numbers, the apparent size of the swarm did not materially vary. A short time before this, M. Fabre had essayed to watch closely the habits of a swarm of wasps (*Vespa crabro*), which the wasps resented by severely stinging him. At the sight, then, of this enormous concourse of *Anthophoræ* a cold shiver crept over him, as he was apprehensive that his temerity would be rewarded by thousands of darts being thrust into him. And yet, he remarks, it was necessary to penetrate the formidable swarm, in order to throw every possible light on the questions he wished to answer. He determined, then, to overhaul the nests, and with lens in hand to watch as long and as patiently as possible, in order to discover what happened in the formation, the re-filling, and closure of the cells. The use of masks and gauntlets was impracticable, since it was necessary to retain his manipulative powers, and to bring his eye close to the lens. A few sweeps with a net enabled him to capture a few individuals which were about to depart, and a few which had just arrived. An examination of these showed that all the females had one or more specimens of *Sitaris* parasitic on the thorax. The circumstances, then, were favourable for closer observation. After arranging his clothes so as to leave as few unprotected parts as possible, he dealt a few blows of the pick-axe in the midst of the swarm, which elicited a *crescendo* note of a threatening character, and soon secured a large clod of earth. The bees, however, did not attack him, and as the clod of earth only contained the cells of *Osmia*, a second sortie was required. This was longer and more leisurely performed than the first, yet the bees did not venture to attack him. Emboldened by this, he stood in front of the nests, detaching lumps of earth, thus causing great disorder by spilling the honey, bruising the larvæ, and crushing the bees in their nests. All this only caused a deeper tone in the constant murmur, without provoking any hostile demonstration. The undisturbed *Anthophoræ* confined their attention to their ordinary work as though no unusual occurrence was in operation. Those whose dwellings had been damaged hastened to repair them, and those which had lost their homes were uneasy at their misfortunes. These bees, then, do not know how to combine together to beat off a common foe, and the individual does not attempt to retaliate unless it is especially assaulted. Owing to this pacific mood, Fabre was able to pursue his researches leisurely for hours, seated on a stone in the midst of the swarm, without receiving a single sting, although no precautions were taken against attack. The people of the country believed that Fabre was engaged in sorcery, and looked upon his tubes, forceps, and other articles as the instruments by which his evil devices were effected. On examining the cells, some were open and contained an incomplete supply of honey. Others were sealed up with a little pellet of clay. The contents of the latter were variable. Sometimes it was a hymenopterous larva which had nearly finished its store of food; sometimes it was a white larva, like the foregoing, but more ventricose and differently shaped; and, lastly, it was sometimes an egg floating on the surface of honey. The honey is fluid, sticky, brownish, and of an exceedingly disagreeable odour. The egg is beautifully white, cylindrical, curved, and about the sixth of an inch in length, while the width does not exceed the $\frac{1}{25}$th part of an inch. This is the egg of *Anthophora.* In some cells this egg only is on the honey, but in many of them a larva of *Sitaris*, of the kind already described, is perched on the egg as on a raft. Here, then, is the enemy in its chamber, but how did it get there? There is not the slightest fissure in the cell by which it could gain access, so that it must have got in before the cell was closed up. Those which contain honey, but no egg, are free from the parasite. Hence the ingress occurs either during the deposition of the egg, or immediately after, and before the cell is sealed up. Experiment, much less direct observation, affords no means of deciding which supposition is the correct one, but a careful consideration of the circumstances of the case would incline one to decide in favour of that which assigns the ingress to the period when the egg is being laid on the honey. Experiment, however, indicates that the parasite dreads the contact of the honey, and if it should become entangled in it, it perishes. If the larva is placed on the wall or edge of a cell containing honey floating an egg, it cannot reach the egg. The parasite must then pass directly from the bee on to the egg, and there is scarcely any other available moment except that when oviposition occurs. Repeated observation demonstrates that one *Sitaris* only gets on to an egg, although the bee may harbour several. Considering how long they have been without food, and how ardently they must be watching the opportunity to pounce on to the egg, how is it that several larvæ do not make a scramble, and how is it they penetrate one by one into the cells in the most orderly way? Almost the only explanation that will satisfy these conditions is that the parasitic larvæ run to the egg as it is half excluded, the size of which is ample for one, but insufficient for two; so that one only can succeed in getting on. The female *Anthophora* having placed her own progeny in the same cell with the enemy of her young, proceeds to cover up the cell; and then renews the same work. On opening the cells which have just been completed, the *Sitaris* larva is to be seen supported on the bee's egg. It is not long before the dark larva, having ceased its exploration of the egg, settles down with its legs spread out, and pierces the egg with its sharp mandibles. Then by jumping violently on it he bursts the outermost membranes, and greedily devours the fluid which exudes. The real food of the larva is the honey, and the destruction of the larva is considered by Fabre as a precaution, since there is not sufficient honey for the two larvæ. When the contents of the egg are disposed of, the larva remains on the collapsed membrane for days, sometimes lying motionless, and sometimes running about, but very careful not to touch the honey. It is curious how strong the impulse is which induces the larva to destroy the egg. If, for example, a larva is placed on a scrap of paper, which answers the purposes of a raft quite as well as the egg, it runs over its surface, but not finding it to answer some urgent want, it makes every effort to escape, and, falling into the honey, is suffocated. If, again, a larva is placed by artificial means on to an egg of *Anthophora*, it soon recognises it as a suitable resting-place, and takes up its quarters contentedly. The egg, then, supplies an essential want, and this fact accounts for the failures which M. Fabre had previously experienced in finding suitable food for them. At the end of eight days the egg is reduced to a dry pellicle, and the larval *Sitaris* has increased to twice its original proportions. The membrane along its back splits, and through the fissure is pushed the head and three thoracic segments of the second larval stage. By-and-by, a little white larva makes its full appearance, tumbles over on to the honey, and from thence derives its future nourishment. The moult is left on the dried-up egg membrane. The second larva is ·078 inch in length, of a flattened oval form, and of a milky-white colour. Its skin is so transparent that a lens enables us to see its digestive tube filled with honey. It has a deep boat-shaped ventral arch, and a flat dorsal arch, the stigmata or respiratory apertures being so situated that when the larva floats on the honey, for which its form admirably fits it, these apertures are raised so high as to be quite free from any danger of being choked up. When the time arrives for it to take up its abode on honey, its organization is adapted for the position. The larva rapidly increases in size, and soon disposes of its stock of honey. But the larvæ of *Anthophora*, when left in possession, gets through it much quicker. By the 25th of June, the latter have consumed the honey, while *Sitaris* larvæ have not acquired more than half their full size, and have a large proportion of the honey still beneath them. The *Sitaris* requires thirty-five days for its repast, while the *Anthophora* finishes it in about a fortnight. In the first fortnight of July the *Sitaris* larva acquires its full size, and is situated at the bottom of the empty cell, along with a heap of reddish excreta. At this period it is white, soft, about half an inch in length, and one quarter of an inch in its greatest width. When on the honey it is buoyed up by its excessively protuberant abdominal region, so that in this case corpulency is of the highest advantage to the owner. There are thirteen segments, including the head, which is light-coloured, soft, and very small relatively to the size of the body. The antennæ are short, and consist of two joints. No eyes are perceptible, and are not required, although in an earlier stage, when sight must be an advantage, there are four ocelli. The labrum is prominent, not distinctly marked off from the head, curved in front, and fringed with pale slender cilia. The mandibles are small, reddish at the tips, obtuse, and excavated on the inner side into the shape of a spoon. Below the mandibles is a fleshy lobe, with two very small papillæ, which is the lower labrum with its two palpi. It is flanked on either side by two other fleshy projections, each provided with a rudimentary palpus; these form the future jaws. The whole buccal apparatus is incapable of motion, and the parts are so rudimentary as to render their description difficult. The labrum and the complex lobe formed by the lip and jaws are separated by a fissure, in which the mandibles play. The legs are mere rudiments, and are formed of three small cylindrical segments. The animal is unable to use them on the honey, and still less so on a solid surface, for when placed on such a surface the protuberant stomach prevents the feet from touching the basis of support. In such a situation it remains almost motionless, the nearest approach to locomotion being feeble wriggling, effected by weak abdominal flexions. The feet are not moved, and if they were would not assist the animal to stir. There are nine pairs of stigmata, one on the mesothorax, and the remainder on the eight anterior abdominal segments. The last pair consists of minute and rudimentary stigmata. The first larva is adapted for acting, and getting possession of the coveted cell; the second is adapted for digesting its contents when acquired. The alimentary canal is precisely like that of the adult *Sitaris*, which, however, takes no nourishment. In both, the œsophagus is short, both have a chylific ventricle, which is empty in the perfect insect, but distended with an orange-coloured paste in the larva; in both there are four biliary vessels, which are attached to the rectum by one extremity. Neither have salivary glands, or any organ analogous to them. The fatty tissue is formed of large white lobules; the nervous system consists of eleven ganglia, not reckoning the œsophageal collar, while in the perfect insect there are only seven ganglia, three being situated in the thorax, and four in the abdomen. When all the provisions are exhausted, the larva remains stationary for a few days, discharging reddish ejectamenta, until the digestive tube is emptied. Then the animal contracts and gathers itself so as to detach its body from the outer skin. Thus enveloped in a closed epidermic sac of great tenuity and transparency, it undergoes a further change of form. The case is so transparent that the animal can be seen within it. All the external organs are preserved in form in the outer or detached skin of the second larvæ; the head, the antennæ, the mandible, the palpi, the thoracic segments with their rudimentary feet, the abdomen with its line of stigmatic orifices—all are preserved in the moult as clearly as they would be in a cast. Within this envelope, which will scarcely resist the touch of a feather, is a soft white mass which soon acquires firmness of texture, and a silvery fawn colour. Breaking the envelope we see the third larval stage. It is an inert, segmented body, of an oval outline, horny consistence, similar to that of pupæ and chrysalides, and of the colour above described, which may be likened to that of certain jujubes. Its upper or dorsal surface is a doubly inclined plane with a smooth ridge, or like the anticlinal arch of the geologist; the ventral surface is flat at first, but owing to evaporation it becomes concave. The length is about half an inch, and the width about one-fourth of an inch. At the cephalic end is a kind of mask, rudely modelled to the form of the larva's head; and at the opposite extremity is a small circular disk, with a deep depression in the centre. Each of the three segments which immediately follow the head have a pair of small pimples which represent the feet. Along the sides are nine stigmata, situated as in the second larva. Each stage in the development seems to result in a simplification of the organism; and Fabre says that the conditions here designated the primitive larva, the second larva, and that which has just been described have hitherto been unknown amongst *Coleoptera*, or even in the whole class of insects. If, he observes, this last stage resembles, on the one hand, the pupa of *Diptera* in its horny substance, the immobility of its segments, the almost entire absence of modelling indicative of the regions in the perfect insect, it is analogous, on the other, to the chrysalis, since the animal before reaching this stage is obliged to cast its skin. It differs from the pupa, since its covering is not the superficial horny integument of the larva, but a more internal membrane; and it differs from the chrysalis in not having the bold sculpturing which maps out the future appendages. It differs still more profoundly from both pupa and chrysalis, inasmuch as it changes into a larva like that from which it originated, and not into the perfect insect. A new organization requires a new name, and Fabre calls it *pseudo-chrysalis*; while the larva into which it is developed is termed the third larva. The pseudo-chrysalis remains stationary for many months, and presents the same internal organization as the second larva. Some individuals of *Sitaris*, however, pass a month only in the pseudo-chrysalis stage, and become perfect insects in September; but most of them retain this condition throughout the winter, completing their transformations in the following June. No material alteration takes place in its external portion, but great changes are effected internally. When in the collapsed state of its ventral surface, already referred to, a cross section would have the form of a spherical triangle. In the spring the collapsed condition is lost; it swells out into an ellipsoidal ball, as though it were being blown out. The horny integuments of the pseudo-chrysalis are detached in their entirety from their contents without any rupture occurring, just as happened before with the skin of the second larva. Thus is formed a new envelope, having no connection with its contents, and which is itself enclosed in a case which was originally the skin of the second larva. There are two closed sacs, one within the other. The outermost is transparent, flexible, colourless, and of the utmost delicacy; the second is almost as flimsy as the first, but less translucent, owing to its fulvous colour, which gives it the appearance of a thin lamina of amber. On the second sac can be seen the stigmatic ridges, the thoracic buttons, &c., which were perceptible in the pseudo-chrysalis. Within this last can be seen a something which looks like a reflected image of the second larva, and the removal of the envelope shows that there is such a close resemblance that the third larva may be described in almost the same words as the second. There are differences, but they are very slight. The third larva has a much flatter ventral surface, due to the digestive cavity not being distended; it has a double row of fleshy cushions along each flank; the margins of the stigmata are slightly prominent; the orifices on the eight abdominal segments are as large as in the others, not rudimentary, as in the second larva, and the mandibles are sharply pointed. When removed from this double enclosure the third larva bends its body about somewhat more energetically than the second, but its feet are still of no service as locomotive organs. By means of the slow contractions and dilatations of its abdominal segments it is able to turn over in its cocoon-like prison, so as to reverse the position of the head. This operation takes about a quarter of an hour to perform. What the object or purpose of this manœuvre may be has not been ascertained. Two days after this it becomes as torpid as the pseudo-chrysalis, although no apparent change in the organization has occurred. This torpidity is interrupted during the assumption of the pupa stages, but recurs again until thrown off when the pupa passes into the perfect beetle. The reversed position is maintained throughout, and, to one who has not witnessed the change of position, the phenomenon appears inexplicable, owing to the prolonged torpidity of the organism in its later phases. This inversion, however, is only found in the pseudo-chrysalides which have been kept in an abnormal position, as in a bottle. It is not observed in those pseudo-chrysalides which have not been removed from the cells of *Anthophora* in the nest; since in these the second larva takes up the proper position at once, whereas in the bottle Fabre paid no attention to the correct relative positions. The changes which are passed through by the third larva are the same as are experienced by most coleopterous insects. The pupa is only the perfect insect swaddled up with the attached limbs and antennæ as limpid as crystal, tucked up underneath the body. Some weeks elapse before the livery of the adult is assumed, and in about a month it undergoes the last metamorphosis. The elytra and wings of the pupa are of a uniform yellowish white, while the abdomen, the larger portion of the feet, and nearly all the rest of the body become a shiny black. In the course of twenty-four hours the elytra acquire their black and white particolouring, and the wings become darker. For a fortnight after this the perfect beetle remains in the cocoon, discharging little patches of uric acid. Towards the middle of August it bursts the double envelope around it, pierces the lid of the cell of *Anthophora*, runs into the galleries, and carries on an active search for individuals of the opposite sex.

The life history of *Meloe cicatricosus* has not been so fully studied, but many of the gaps can be conjecturally supplied by reference to what occurs in *Sitaris*, as narrated above. The same mason bee, *Anthophora pilipes*, at whose expense *Sitaris humeralis* is supported, also nourishes the above-mentioned species of *Meloe* in its cellules, but the *Meloe* is rare as compared with *Sitaris*. This *Meloe* is also found in the nests of *Anthophora retusa*. But although found in the dwellings of the bees under the same circumstances as *Sitaris*, the perfect females were not observed by Fabre to lay their eggs just within the entrance to the galleries. From the testimony of other observers, such as Gödart, De Geer, and Newport, the eggs are deposited on the soil, generally on some place where it is dry and exposed to the sunshine. The female digs a hole about two inches deep, wherein a little heap of eggs are placed, and the hole covered up again. This oviposition is repeated three or four times during the season, an interval of a few days occurring between the laying of each batch of eggs, and a fresh hole being dug on each occasion. This occurs during April and May. The number of eggs yielded by each female is extraordinary. The first deposition is the largest, and in the case of *M. proscarabœus* consists of upwards of 4000 eggs. The eggs of *Sitaris* are to all appearance placed in as dangerous a spot as could be selected, and since the fecundity of *Meloe* so much exceeds that of *Sitaris*, the young of *Meloe* are probably exposed to still greater dangers, and the increased fecundity is proportioned to the greater chance of destruction. The eggs are hatched in May or June, from 20 to 36 days after the laying, the time varying according to the character of the season. On the average, the hatching time probably lasts a month, which nearly corresponds with the time required for the same purpose by *Sitaris*. But the *Meloe* larva appears when it can at once commence its search for the mason bee, without having to undergo the long preliminary deprivation of food experienced by *Sitaris;* and that it soon effects its object is evident, since it may be frequently met with as a little yellow parasite on the down of bees in spring. How does it contrive to transfer itself from the hole in the ground to the body of a hymenopterous insect? Newport believes they crawl up the plants in the vicinity, more especially those belonging to the *Cichoraceæ*, conceal themselves amidst the petals, where they await the visit of insects. Some authors consider that they select certain species and reject others, but Fabre thinks they will cling to any insect that has a sufficiently downy covering, the more so since they have been detected on a great many species of widely different habits and affinities. He thinks that in taking so many different conveyances the Meloes are able in most cases to reach their destination, namely, a cell full of honey, since nearly all the insects on which they occur collect honey. It has been found on the males of *Nomada fulvicornis*, a dipterous insect which does not collect honey. But if, as is believed, this insect is parasitic upon honey-collecting bees, the *Meloe* may succeed even in such cases at getting into the honey jars. But a similar explanation will not apply in all cases. Thus young Meloes have been discovered on the down of *Scolia hæmorrhadilis* and *S. quadripunctata*, which in the larval condition feed on animals on which the female originally laid its eggs. In such case the young Meloes would seem to have missed the mark. So, again, they have been seen on *Eristalis intricarius*, which in its earlier phases is aquatic in its habits. Of a similar import is the experiment by Newport, in which he plunged a specimen of *Malachius bipustulatus* into a jar containing some hundreds of young Meloes, which was so invested by the latter as to be deprived of the power of moving. It is probable, then, that a considerable number perish before they can reach honey. It may be thought that in *Meloe* the object is parasitism on the insect's body, but from the facts afforded by *Sitaris*, and by *Meloe* itself, there can be little doubt that the young larvæ do not live upon the substance of their carriers, but upon the honey in their cells. In order to ascertain what the food was, Fabre tried everything which he attempted in his earlier experiments, but as with *Sitaris*, he could not induce the larva in its earliest condition to drink the honey or eat the hymenopterous larva. Newport made similar experiments, and obtained similar results. The conclusion he came to was, " that the larvæ of *M. violaceus* and *M. proscarabœus* are not parasitic on the half or full-grown larva of *Anthophora retusa;* yet, from the circumstance of their always attacking the larvæ in those experiments, there seems reason to suspect they may prey on the very young of some species of bee soon after it has left the egg, although not in its advanced growth." There is no doubt that *Meloe* is parasitic within the nests of *Anthophora pilipes*, and probably of other species also. M. Fabre found them to be rare where *Sitaris* was abundant; but he succeeded in finding two cells with a larval *Meloe* in each. One cell contained black honey, on the surface of which was a wrinkled pellicle; and on this pellicle was the larva. There is great probability that the larva quits the female bee at the moment of the egg being laid within the cell, and that it resorts to the same manœuvres as *Sitaris* to rid itself of the potential enemy resident in the egg by devouring the egg; and that then it becomes metamorphosed into a being capable of feeding on the honey without being suffocated. Although the object of each step is to get the honey, the larva is not adapted to derive its nutriment therefrom in its earliest condition. The second cell was also full of a sticky fluid, on which floated a small white larva about one-sixth of an inch in length, and therefore much larger than the second larval stage of *Sitaris*. The rapid movements of its abdomen showed that it was feeding vigorously on the stored up nectar. This had every appearance of being a young *Meloe* in its second developmental phase. At a subsequent date, Fabre obtained a few other cells tenanted by *Meloe*. One of the larvæ, which had consumed about half the honey, and a second which had nearly finished it, were preserved. They were blind, soft, fleshy, of a yellowish-white, and clothed with a fine down, in which respect, as also in their general form, they closely resemble the larvæ of Lamellicorn beetles. The segments, inclusive of the head, are thirteen in number, of which nine are furnished with stigmatic orifices, surrounded by pale oval margins. As in *Sitaris*, the last pair, situated on the eighth abdominal segment, is less developed than the others. The head is horny, and slightly brown. The labrum is prominent, white, and trapezoidal. The mandibles are black, strong, short, obtuse, slightly curved, trenchant, and furnished with a large tooth on the inner surface. The maxillary and labial palpi are brown, and like little knobs, formed of two or three segments; the first segment is large and globular; the other two are much narrower, and cylindrical. The legs are short, but strong, and might be used to dig or crawl with. The length of the larva is one inch. As far as could be determined from a specimen long macerated in alcohol, the nervous system consisted of eleven ganglia, and an œsophageal ring. The digestive system does not differ materially from that of the adult. *Meloe* thus agrees with *Sitaris*, in that the larva which attaches itself to the down of a bee and penetrates into its cell, is transformed into a second, having a very different form, and capable of living on honey. One of the larvæ obtained by Fabre, underwent a change a fortnight after he had obtained it. Its skin split on the back, and partially exposed to view a pseudo-chrysalis, exceedingly like that of *Sitaris*. From the robust proportions of the mandibles, and the well-developed limbs, armed with strong nails, Newport conjectures that the larva might be capable of digging, so as to pass from cell to cell in search of nutriment, a supposition which Fabre thinks is supported by the consideration that the larva attains a size which far exceeds the proportions which a single cell-full of honey might be expected to develope. The pseudo-chrysalis, or as Newport termed the same phase of development, the pseudo-larva, is an inert body, of horny consistence, amber-coloured, and divided into thirteen segments. It is about three-fourths of an inch long, slightly arcuate, highly convex on the dorsal surface, nearly flat on the ventral surface, and having the two surfaces separated by a prominent row of tubercles. The head is a kind of mask, on which is vaguely delineated the future elements of the head. On the thoracic segments are shown three pairs of tubercles, corresponding to the legs of the succeeding stages. Finally, nine pairs of stigmata complete the description, which have the same position and general features as those in the pseudo-chrysalis of *Sitaris*. The resemblance between the two is even repeated in many of the minor details. The difference consists in the general aspect, and in the envelope which forms the moult of the larval stage preceding the pseudo-chrysalis. In *Sitaris* it is a closed sac. In *Meloe* it is split along the back, and turned backwards, so that only half the body of the pseudo-chrysalis is covered by it. An autopsy, performed on the only pseudo-chrysalis in Fabre's possession, indicated that, notwithstanding the great changes, no material alteration in the character of the internal viscera, such as the digestive system, occurred in the later metamorphoses; but an alteration occurs in the number of ganglia, which is eight, in the abdominal region of the larva, but only four in the same portion of the perfect insect. It is not known how long the pseudo-chrysalis condition is retained, but judging from what is known of *Sitaris*, it is probable that sometimes individuals are transformed in the same season, while others do not pass into the next phase until the following year. At any rate, pupæ of *Meloe* have been found towards the end of August. The horny integuments of the pseudo-chrysalis are split along a line which extends from the ventral surface, over the head and down the back of the thorax. This moult, rigid and uninjured, is left half enveloped in the skin, abandoned by the second larva. Through this fissure the pupa makes its escape, so that it seems a pupa succeeds the pseudo-chrysalis, which is not the case in *Sitaris*. But such appearances are deceitful, since, on raising the pupa from the split sheaths which formed the pseudo-chrysalid covering, we find at the bottom of this sheath a third moult, the last which the creature had thrown off before assuming the condition of a pupa. This moult still adheres to the pupa by a few tracheal filaments. On softening it in water, there may readily be recognized an organization almost identical with that of the larva which preceded the pseudo-chrysalis. In the last phase, however, the mandibles and legs are not so powerful. The pupa presents no feature that calls for notice. One specimen kept by Fabre became a perfect insect towards the end of September, and it might be thought that under normal conditions this would be the usual time for the beetles to make their appearance. Sexual intercourse and oviposition has only been observed in spring, so that it is more probable that the beetles remain quiescent through the winter, and resume activity in the earlier warm months of the year. These are two examples of some of the most remarkable metamorphisms in the whole insect class, a class which abounds in marvellous changes of form; doubtless the family *Meloidæ* presents others. Fabre, indeed, describes a third kind of pseudo-chrysalis, which he was unable to assign to its proper genus. It was discovered dead in the nest of *Chalicoderma muraria*, the cells of which had long been abandoned. It was not enveloped in the gauzy envelope of the larval stage preceding it, but this may have been brushed away, since the cell in which it lay was much injured. The pseudo-chrysalis is cylindrical, obtuse at both ends, horny, and of a brick red colour. Its surface is ornamented with a multitude of very minute points, from each of which diverge raised rays, so that when looked at with a lens, it seems to be sprinkled with stars. The segmentation is obscure, but a little attention determines the number of segments to be thirteen. In all its other characters it generally resembles the varieties already described. Its occurrence in the cell of a mason bee; its similarity to the pseudo-chrysalis of *Sitaris* and *Meloe* indicate the existence of an insect with the singular habits of those genera. In its first larval stage it is attached to the down of hymenopterous insects, and *Chalicoderma* in particular. Fabre asks if it may not belong to *Zonitis*.

What is the meaning of all these curious metamorphoses, which are so different from what is usually met with in the order *Coleoptera?* The abnormality is confined to the first three phases. At one time Fabre thought that the first and second larvæ, together with the pseudo-chrysalis, were the direct resultant of the fecundated egg; that the pseudo-chrysalis developed another egg by internal gemmation, from which a new larva sprang, to become metamorphosed into a sexual adult. The facts above detailed convinced him of the error of this view. Rejecting this, he starts another train of ideas, to the general effect that all coleopterous insects undergo metamorphism, accompanied with a greater or less number of moults; but amidst these changes no external characters, once acquired, are subsequently lost. Thus the feet are never developed to be afterwards lost; the first stages are not provided with sight to be afterwards deprived of that sense. In the case of such larvæ, there is no radical change in the external conditions upon which their life depends; but if there should be such a change, we should expect that corresponding modifications might occur in the characters. Something of this kind is believed to occur in the *Meloidæ*. The first larva lives on a bee; its perilous rides necessitate rapidity of movement, sharp eyes, and a sensitiveness to changes of equilibrium. In accordance with such conditions, it has a slender, graceful shape, ocelli, legs, and special means for resisting jerks. As soon as it is in the cell, these provisions are unnecessary, but it requires the means to pierce the egg, and its sharp mandibles enable it to do this most effectually. This done, it must be fitted for sucking up the honey; but as it is unable to live in the honey, its structure must be modified, and in this change the eyes, legs, &c., are discarded, as though their presence would be unnecessary and injurious. It is not easy to see the necessity for all the subsequent changes which occur, but each change in the animal seems to have relation to the changed circumstances under which the animal is to live. The preliminary phases which precede those generally met with amongst *Coleoptera*, Fabre proposes to call *hypermetamorphosis*.

When a student is brought face to face with facts of this kind, he is strongly impressed with the manifest design displayed in many of the phenomena. The way in which that design is fulfilled evinces a sagacity and fertility of thought far transcending the mental powers of a *Meloe* or a *Sitaris*. There is some unseen Power at work behind the scenes, which guides everything unerringly. How this Power acts we are unable to say; but so far as the writer can judge, it seems to be by the indirect agency of natural laws rather than by the direct manifestation of will.

(Fabre, *Annales des Sciences Naturelles*, Quatrième Série, tome vii. p. 299—365.)

MENZIESIA, a genus of plants belonging to the natural order *Ericaceæ*, or Heath-worts. It is distinguished by the calyx being four or five leaved, the bell-shaped corolla having four or five reflexed teeth, eight stamens, and a blunt stigma. Most of the species are natives of North America, but they are frequently met with in the high northern or alpine floras of the old world. The distribution of some species is noteworthy. Thus *M. cærulea* is spread over large areas of country in high northern latitudes, but on advancing south it is absent over tracts hundreds of miles in extent, but recurs again in a few isolated spots in the higher mountainous regions of the south, such as the Pyrenean range. These little groups of individuals occur like the outliers of certain strata. The geologist considers such detached patches of strata as a proof of the former extension of similar beds over all the intervening region which originally had the same level as the strata themselves. The gaps have been formed by the removal of the rocks, &c., by denudation. In like manner these patches of plants frequently indicate that at one time the specific area was continuous, and that the absence of the species from the regions forming the gap has arisen from alteration in the conditions, principally climatic, which the plant requires for its maintenance. *M. cærulea*, then, formerly ranged over the whole of western Europe, whereas now it is almost entirely restricted to the more northern and the more southern regions. What are the conditions which have favoured the extension, and why has the species since lost ground? A close examination of the southern outliers, together with a consideration of the circumstances under which the living individuals flourish, leave little doubt that the principal cause favouring the extension was the former prevalence of an extreme rigour of temperature over all Europe, and that the subsequent amelioration of that temperature has driven it from the warmer plains into the higher and colder areas, thereby separating the southern colonies from the main specific area. In this connection the fact that *M. cærulea* is only known in a single locality in the British isles, a mountain in Invernesshire, where it is exceedingly rare, is interesting, since we understand why the plant should be so local and so rare. Some years back the colony, as was thought, was exterminated by a nurseryman, but specimens gathered within the last few years prove that the species has not quite died off the British area. Why should relics such as these be ruthlessly destroyed? Archæologists exert themselves to protect from unnecessary destruction the venerated antique works of their forefathers; and botanists ought to use their endeavours to avert the premature extinction of relics, like *Menziesia* in Scotland, which were established long before the oldest barrow was erected or the first rude temple of stones was founded.

MERYCOIDODON. [OREODON, E. C. S.]

MILIOLIDÆ. [FORAMINIFERA, E. C. S.]

MIOCENE, the name for a geological period and group of strata intermediate between those periods and strata for which the terms Pliocene and Eocene have been appropriated. The limits of the period are not defined by the dates of certain remarkable occurrences as is usually the case in the periods of human or historic chronology; but arbitrarily by the proportion which the extinct species of mollusca bear to those which were then living and have survived to the present time. Such a mode of definition is open to many objections; but since for the purpose of accumulating and arranging facts a bad method is better than none at all, and since no better has been proposed, it has received general acceptance. So far as we can gather, all those beds are referred to the miocene period which contain more than fifty, and less than eighty, per cent. of extinct mollusca; and if the beds should not contain fossils, their relative age may generally be arrived at approximately by a consideration of their stratigraphical position. In this place, however, we do not propose to describe the succession of the strata of each country in detail, or to point out the varied faunas and floras which have been obtained from them, but will satisfy ourselves with a very general allusion to them. Most of our space will be devoted to a consideration of the bearing of some of the facts or indications of the climate of the miocene period. On this subject Professor Heer, of Zurich, is the chief guide, and we shall accordingly follow him.

The eocene flora of Europe is represented by specimens gathered at a few localities of very limited area; but the miocene flora is represented by specimens from places scattered all over Europe, so that it may be hazardous to state positively what were the general features of the floras of the various tertiary periods. But taking the facts that are accessible, they indicate that the eocene flora was tropical in its character, and most allied to the living Indo-Australian flora, and that the more characteristic American forms are poorly represented. The lower miocene flora is of a less tropical character; the Indo-Australian forms are still predominant, while the deciduous trees similar to those which form so conspicuous a feature in the present European forests first acquire importance, and there is a closer approximation to the American species. During the later miocene period the tropical types formed an appreciable proportion of the flora, the genera of sub-tropical and temperate regions predominated, the American character of the vegetation had become more decided, and the genera which now characterize the floras of the Mediterranean region and of the neighbouring Atlantic isles, were first introduced. At a later period, that named pliocene, the genera of tropical regions diminish, and those of warm regions increase, in importance, and the American character is still conspicuous. A large proportion of the species lived on from miocene into pliocene times, but nearly all correspond to such as now thrive in warm and temperate climates. As we come nearer to the present time the species acquire more and more nearly their present geological distribution, so that most of those which have been found in post-pliocene beds are still to be found living in the same district in which they grew during the post-pliocene period. The modifications in the floras seem to indicate a gradual depression of the temperature from the eocene period to the present time. Such are Professor Heer's general views, which he supports by descending into still further detail, and even attempting to ascertain what was the mean annual temperature of each period. We believe that too much importance is attached to the influence of the temperature in regulating the geographical distribution of plants at different periods, and that, although Professor Heer's main conclusions may be correct, the logic is not sound. Some of the reasons for so thinking are, that while temperature has undoubtedly considerable influence on the prosperity of plants, still there are other conditions almost, if not quite as influential, modifications in which would probably enable the plant to flourish best under a colder or a warmer climate. Again, it is to be noticed that the plants of the miocene period of one country only do not all indicate the same climate: some are analogous to the tropical species, others to those which are now restricted to much colder latitudes. If the tropical species can now only thrive in a very hot country, and the temperate zone species in a cool country, how is it that they flourished together on the same area in former times? One answer might be that the district had a bold orographic outline, that the tropical plants inhabited the plains, and the temperate species the highlands. But so far as we can gather, the country was less boldly modelled in the miocene period than it is now. Another reason, of a more cogent character is, that amongst plants, and also amongst animals, many cases have been observed in which a group living together on a certain area at a particular period, is found to have spread out at a subsequent period, and to have become differentiated, by which we mean, that one portion has migrated in one direction, and another in the opposite. This is the case with the miocene flora, whose analogues are now met with in the direction of all points of the compass. We believe that modifications of physical geography will afford the true clue to the efficient agents which have brought about the shifting composition and distribution of floras, and that consequently the best hypothesis will be based upon a consideration of the changes which have taken place in all the elements of physical geography of which temperature is only one out of many. With this digression, which is inserted by way of caution, and not with the slightest intention to refute Professor Heer's arguments, we will resume the Professor's train of reasoning. The principal indications of a warmer climate in Switzerland are the great number of species; the large proportion of ligneous plants; the prevalence of evergreen shrubs and trees; the relative annual season when the trees put forth their leaves and blossoms; and the general character of the vegetation, which, while comprising numerous tropical genera, resembles most nearly the present flora of the southern United States, next, that of the Mediterranean area, and lastly those of the Canarian and Japanese isles. The composition alone negatives the idea that the climate was like what middle Europe now has, because the winters of that area would now cut off the palms, the laurels, the evergreen figs, the *Acacia Cæsalpinia*, the camphor plants, and the cinnamon shrubs. On the other hand the presence of pines, beeches, poplars, elms, nut-trees, and others, show that the climate was not tropical. In order to illustrate his idea Professor Heer gives a table of the present distribution of the nearest living representatives of the Swiss miocene, which he divides into four stages. This table also seems to illustrate the wide dispersal of the ancient Swiss flora.

	EUROPE.		ASIA.			AMERICA.				AFRICA.		AUSTRALIA.
	Middle.	Mediterranean zone.	Temperate zone.	Warm zone.	Torrid zone.	North United States.	South United States.	Tropical.	Chili.	Atlantic Isles.	Rest of Africa.	
1st stage .	23	23	7	25	17	35	40	27	1	12	14	14
2nd stage .	20	24	12	22	7	30	40	23	1	1	4	5
3rd stage :	9	11	6	11	4	10	16	10	1	2	2	3
4th stage. .	49	54	23	43	13	67	69	25	2	8	12	8

It is thought that these facts indicate a nearly uniform temperature throughout the first three stages, and a slight decline in the fourth. The climate of the lower miocene is considered to be somewhat like those of Tenerife, Tunis, South China, and the vicinity of New Orleans, where the mean annual temperature ranges from about 68° F. to 72° F.; while that of the upper miocene is thought to have had a climate similar to those of Madeira, South Spain, Japan, and New Georgia, in which countries the mean annual temperature is not far from 65° or 66°. Professor Heer, however, expressly points out that none of the recent climates referred to was precisely like that of the Swiss miocene, which doubtless had peculiarities of its own. The commingling of tropical and temperate plants indicates an equability of the seasons, such as is usually characteristic of insular districts. He enters into calculations which lead to the probability that the local circumstances being the same, the temperature was about 16° F. higher than at present during the lower miocene, and rather more than 12° F. higher during the upper miocene period. The relation of the temperature of the miocene to that in the periods before and after may be gathered from the following table. If the facts are correct, it affords material towards arriving at a most important generalisation, viz., the rate at which the temperature has declined during the tertiary epoch :—

Eocene (Upper)	78°—80°
Miocene (Lower)	68°—70°
Miocene (Upper)	65°—66°
Pliocene of Tuscany	63°—65°
Glacial period	41°
Present period	48°

Professor Heer then gives long lists of the mammalia, insects, and other classes, and points out how they corroborate the conclusions based on the plants, for which details the reader is referred to Professor Heer's work. The extent to which the miocene flora flourished towards the poles is one of the most remarkable facts connected with this subject. In North Greenland, lat. 70° N., species of *Sequoia*, identical with those which flourished at the same period in England and Switzerland, have been found in miocene strata along with poplars, willows, beeches, oaks, walnuts, and numerous evergreens. There is no question that these lived on the spot, and were not drifted to the locality. Farther north, in Spitzbergen, lat. 78° 56′ N., a flora of nearly one hundred species has been detected of this age, and amongst other species there occur two belonging to the genus *Taxodium*, a hazel, poplar, alder, beech, plane, and lime. Such facts speak very decidedly in favour of a warmer climate, since these latitudes will now only support a very few species of dwarf plants, and the repressive influence is, there is very little doubt, the exceedingly low temperature. It is probable that vegetation may have extended all over the northern hemisphere in miocene times, since at the present time willows, limes, and other hardy genera range from 4° to 10° farther north than the planes, beeches, *Taxodium*, &c.; these latter, as we have seen, occur north of 78°, so that willows might have extended to 88° or even 90°.

Having referred to the high temperature of the period, we will now briefly allude to a remarkable set of phenomena which seem to imply a considerable degree of cold in a region so far south as Turin. In the neighbourhood of that city is the hill of Superga, composed of a conglomerate assigned to the upper miocene group of strata. This conglomerate is in part made up of large blocks, some of which are 14 feet long, and one has been found which was 26 feet long. Many of them are angular, and a few of them are faintly striated and polished on one side. At the present time the nearest strata *in situ* similar to the larger blocks is distant some twenty or more miles, but the country has been so altered that it is difficult to say where the blocks have been transported from. If they have been transported from a distant locality, as certainly seems to be the case, one is almost compelled to infer that ice existed in such considerable quantities as to imply a glacier-generating land. If the northern hemisphere was covered with verdure, and swarmed with a varied animal life, it is hard to conjecture where such a land could have been. There are also apparent indications of miocene glacial beds amidst the strata of the Pyrenees.

(Heer et Gaudin, *Recherches sur le Climat et la Végétation du Pays Tertiaire;* Lyell, *Elements of Geology*, 6th Edition; Lyell, *Principles of Geology*, vol. i. 10th Edition.)

MOHO. The name given by the New Zealanders to *Notornis Mantelli* [NOTORNIS, E. C. S.]

MOLA, a name which is sometimes given to a group of plectognathous fishes, usually named *Orthagoriscus*, and familiarly known as sun-fishes. The genus is more appropriately noticeable under *Orthagoriscus* [ORTHAGORISCUS, E. C. vol. iv. col. 133], but here we would briefly refer to the memoir by Steenstrup and Lütken, in which a critical examination is given of the genus under the name of *Mola*. According to them it includes three species only, viz., *M. nasus*, *M. Retzii*, and *M. truncata*. They describe the greater modifications of form, physiognomy, and integumental peculiarities which are developed in the same individual during its lifetime, and indicate how some ichthyologists have considered these characters to be demonstrative of distinct genera, and even families. The genera *Molacanthus* and *Acanthosoma*, as also the family *Molacanthidæ*, are based upon what are really individual differences.

(Steenstrup and Lütken, *Oefv. Dansk. Vidensk. Selsk. Förhandlingar* for 1863, p. 36).

MOSASAURUS [E. C. vol. iii. cols. 900—902]. At the conclusion of the E. C. article a slight reference is made to the occurrence of some remains belonging to this genus in North America. By what appears to be a slight misprint it seems that Dr. Harlan discovered some teeth in Philadelphia; but the correct reading we have little doubt is that they were found by Dr. Harlan, of Philadelphia, in the vicinity of Woodbury, New Jersey. Many other remains have been obtained from the same state, more especially in Burlington and Monmouth counties; fragments of the skeleton and isolated bones have also been met with in Alabama, in the region through which the Upper Missouri flows, and in a few other states. The most important remains are those discovered on the Upper Missouri in the vicinity of Big Bend. They consisted of a greater portion of the skeleton, and comprised an almost complete skull, and eighty-seven vertebræ. They were fully described by Dr. Goldfuss in the 'Transactions of the Academy of Bonn.' ('Nova Acta C. L. C. Nat. Cur.' xxi. p. 173.) Although the materials relating to this genus are increasing, it does not appear that there is yet sufficient to enable one to form a clear idea of its structure and affinities. Professor Leidy has given very full accounts of all the American remains accessible to him. He seems inclined to refer most of the fragments to one species only, viz., *M. Mitchelli;* but he indicates that it is possible that they may belong to several species; if, however, they do belong to one species, the range of variation was extraordinary. His memoir is an important contribution to the literature of the subject, as he points out the minute differences, and shows how the characters of the teeth are correlated with their position in the jaw. He also dwells upon some features in which the American remains differ essentially from the *Mosasaurus* of Maestricht, as described by Cuvier, Owen, and others. This will be perceived from the following summary which he gives of the conclusions arrived at by former observers and by himself. The original account is abundantly illustrated with figures and references.

He dwells upon the great diversity in the size and form of the teeth found in the United States, and remarks that he hesitates whether they should be assigned to one or more species of the same genus or to several genera. The difficulty is not lessened by the circumstance that examination of the casts, figures, and descriptions of the Maestricht specimen does not enable one to detect those minute shades of character which would materially assist in settling such doubts. He then goes on to say that Cuvier's description of the teeth of *M. Camperi* is general, and that "he observes that they are all pyramidal, and slightly curved; their external face is plane, and defined by two acute ridges from the internal face, which is round or demiconical. Subsequently he remarks that the ridges are entire, and without denticulation. He does not refer to the existence of divisional planes upon the teeth; and an inspection of undoubted teeth of the genus leaves no question that the ridges of the crown are minutely denticulate in the unworn condition. An examination of the cast also proves that there is some diversity in the shape of the teeth in different parts of the series. Goldfuss, in describing the teeth of *Mosasaurus*, says they are slightly compressed laterally, towards the apex feebly curved backwards, and are divided into a large inner and small outer half by an acute linear ridge, which is transversely striated. Their surface appears polygonal, the outer surface presenting five, the inner seven pyramidal planes. Professor Owen, in referring to the description of Goldfuss, remarks, that 'the feeble indications of angles observable in some of the teeth, those of the upper jaw chiefly, of the *Mosasaurus Hoffmani*, do not bear out the term polygonal which he applies to the crown of that species, as well as to those of his *Mosasaurus Maximiliani*; still less can I find these angles so constant and regular as to divide the outer surface of the crown into five, and the inner surface into seven facets.' The plaster cast of the jaws of the Maestricht Monitor shows that the front teeth are narrower than those behind. The external surface of the crown is comparatively narrow, and slightly convex, while the internal surface is of considerable extent, forming in section the transverse half of an ellipsoid. In passing backward in the dental series, it appears that the external surface of the crown increases in breadth, and becomes more convex, while the internal surface in a corresponding manner decreases. In the back teeth the crown appears to be laterally compressed concave, with the external surface nearly as wide and convex as the internal, so that a transverse section presents an ellipse with acute poles. Thus the front teeth of the cast correspond with those usually described as characteristic of *Mosasaurus*, while the back ones are more like those supposed by Professor Owen to indicate a distinct genus, which he has named *Leiodon*. In most of the teeth usually assigned to *Mosasaurus*, the inner and outer surfaces of the crown are more or less distinctly subdivided into a series of narrow planes, which are most evident towards the base of the crown. These planes are variable in number, and are often slightly depressed or feebly concave. They are sometimes multiplied towards the base, but become indistinct, or even disappear at the summit. In the plaster cast the divisional planes of the surfaces of the crown, while sufficiently evident in the more anterior teeth, appear to be obsolete in those most posterior, though it is true that their absence in the latter may arise from defective modelling. In the Maestricht Monitor Cuvier observes that 'the teeth are hollow only during their development, as they are then in all animals. They become filled throughout their length, and are most frequently found entirely solid. They complete their development in becoming attached to the jaw by means of an osseous body very different in structure from that of the tooth, with which it is nevertheless intimately associated. The successional tooth originates in a special alveolus produced at the same time, and it penetrates the osseous body of the tooth in use. In enlarging, the successional tooth finally detaches the osseous body from the jaw, with which it was organically united; the body by a sort of necrosis being shed, and carrying with it the tooth it supported. Gradually the successional tooth, with its body, improperly called its osseous root, assumes the position from which the old one was removed.' Subsequently Cuvier, after remarking that 'he had formerly committed the error of calling the osseous structure connecting the tooth with the jaw the root,' observes that 'he had since recognised it to be the dental pulp, which, instead of remaining soft as in mammals, becomes ossified and identified with the alveolus.' Cuvier continues: 'The tooth has no true root, but adheres strongly to the pulp which secreted it, and is further held in connection with it by the remains of the capsule which furnished the enamel, and which by becoming ossified also, and uniting itself with the maxillary bone and ossified dental pulp, inserts and fixes the tooth with additional force.' Again, in comparing the mode of implantation of the teeth of *Mosasaurus* with the living *Monitor* and *Iguana*, Cuvier observes of the former that 'the socles (pedestals) or ossified pulps, which support the teeth, are adherent in hollows or true alveoli contrived in the thickness of the border of the jaw.' Goldfuss, referring to the Maestricht and Missouri *Mosasaurus*, says, 'In both, the crowns of the teeth, invested with shining enamel, are sustained upon the dental capsule which is transformed into an osseous socle, co-ossified with the alveolus, and they are in part hollow internally and in part solid.' Owen, in his 'Odontography,' p. 258, in reference to *Mosasaurus*, observes that 'the maxillary teeth combine the pleodont with the acrodont characters.' Further on he continues: 'Its dentition exhibits in an eminent degree the acrodont character; the teeth being supported on expanded conical bases anchylosed to the summit of the alveolar ridge of the jaws; no existing saurian exactly parallels this mode of attachment of the teeth, either in regard to the breadth of the alveolar border or in the relative size of the osseous cones to the teeth which they support. A shallow socket is left where the tooth and its supporting base are shed.' The same authority in a more recent work, 'Palæontology,' p. 279, remarks that 'the teeth are anchylosed to eminences along the alveolar border of the jaw, according to the acrodont type.' Pictet, in his 'Traité de Paléontologie,' vol. i. p. 504, speaks of the teeth of *Mosasaurus* as being deprived of true roots, and anchylosed to the jaw. Gibbes in his 'Memoir on the *Mosasaurus*,' follows the descriptions of Cuvier and Owen. Gervais, in the 'Zoologie et Paléontologie Française,' vol. i. p. 262, in describing some teeth which he refers to *Leiodon*, observes that, as in *Mosasaurus*, they are inserted in alveoli, with which their base is identified by means of the surrounding layer of cement. In a note he adds the remark, 'C'est à tort que l'on décrit les dents des *Mosasaurus* comme réellement acrodont à la manière de celles de beaucoup de Sauriens actuels.' From the fossil specimen I have had the opportunity of examining, the history of the dentition of *Mosasaurus*, so far as I have been able to trace it from the imperfect materials, appears to be as follows:—The mature teeth of *Mosasaurus* have curved conical crowns, with long, robust fangs inserted into sockets or alveoli, with which they were at first connected in the ordinary manner by connective tissue, but with which they subsequently became firmly co-ossified. They contain in the interior a large fusiform pulp cavity, communicating through a canal with a funnel-shaped pit at the end of the fang. The conical crowns of the teeth are curved backward with an inclination inward; the curvature being more rapid approaching the apex. They are generally divided in front and behind by an acute ridge into an inner and an outer surface. In some teeth apparently belonging to the most posterior of the dental series of the jaws, and to those of the pterygoid bones, there is only one ridge, which is situated along the back or concave border of the crown. The ridges exhibit a minutely crimped and subdenticulated arrangement which was obliterated by wearing. The proportionate extent of the inner and outer surfaces of the crown, as defined by the two ridges above indicated, varies very much in the different specimens of fossil teeth, apparently according to the position the latter occupied in the dental series. In those teeth which I suspect to belong to the anterior part of the dental series the crown has the form corresponding with the descriptions which have usually been given as characteristic in general of the tooth of *Mosasaurus*. It is very unequally divided by the acute ridges; the inner surface occupying two-thirds or more of the extent of the crown. The convexity or transverse curvature of the outer surface forms a short segment of a comparatively large circle; that of the inner surface forms one half to two-thirds or more of a circle, whose diameter is that of the crown. The transverse section of the crown might be appropriately called shield-shaped. In those teeth which are supposed to belong to the middle of the dental series, the disproportion between the outer and inner surfaces of the crown is comparatively trifling, and the transverse section is circular or nearly so. Teeth attributed to the more posterior part of the dental series have their crowns compressed from within outwardly, and nearly equally divided by the acute ridges, and in transverse section are elliptical with acute poles. Finally the last teeth of the series have compressed crowns, with a single ridge and an ovate transverse section. The inner and outer surfaces of the crowns in most of the fossil teeth are unequally divided into narrow planes, variable in number. They slightly multiply towards the base of the crown, and become fewer and less distinct, or altogether disappear towards the apex. They vary in degree of distinctness in different teeth, and in many do not exist at all. The fossil teeth under examination would appear to indicate that the subdivision of the inner and outer surfaces of the crown is best marked in the anterior teeth of the series, becomes less evident in passing backward, and ceases in the last teeth. Some of the specimens would appear to show that the subdivision of the crown held some relation with the age of the animal; not existing in the young, but developed in the mature animal. Other specimens appear to indicate that the difference was due to individual peculiarity, or perhaps in some it may denote a difference of species if not of genus. The fangs of the teeth of *Mosasaurus* are remarkable for their great proportionate size, being several times the bulk of the crown they support. From the enamel border of the base of the crown the fang expands in the form of a cone to the entrance of its socket, where it presents its greatest diameter, and is more or less defined by a shoulder or ledge. The intra-alveolar portion of the fang from two to four times the length of the extra-alveolar portion is straight, oblique slightly curved, cylindroid and slightly narrowed towards the obtusely rounded end. Frequently it is more or less compressed from without inwardly, and occasionally wrinkled at bottom. The mature fang was at first simply inserted about three-fourths or more of its length in its socket, with which it was evidently adherent in the ordinary manner by connective tissue. Subsequently, however, it became firmly co-ossified with the alveolus; the ledge or base of the extra-alveolar portion with the entrance of the alveolus at the border of the jaw; the intra-alveolar portion with the sides and bottom of the alveolus. The pulp cavity of the mature teeth of *Mosasaurus* occupies a large extent of space in their interior. It is fusiform, or doubly conical, one cone extending into the crown, the other into the fang. It communicates by a large canal with a funnel-shaped pit, usually more or less compressed at the bottom of the fang. Occasionally the fang is occupied by a coarse cementum pervaded by many large vasculo-neural canals. The crown of the teeth of *Mosasaurus* is composed of compact dentine invested with a thin layer of enamel. At the base of the enamelled crown the dentine extends in the form of an inverted cone, within the extra-alveolar portion of the fang, and terminates in a thin, abrupt annular margin, encircling the pulp cavity. The dentine presents the ordinary constitution of an amorphous substance pervaded with innumerable canaliculi diverging from the pulp cavity to the periphery of the crown, dividing in their course and giving off multitudes of lateral anastomosing branches. Below the enamel border of the crown the dentine is defined from the cementum of the extra-alveolar portion of the fang by a more amorphous bond of union of the two structures. The fang is composed of cementum or bone. It is mainly composed of vertical osseous fibres, pervaded by numerous vascular canals pursuing the same course as the former. It is of much finer texture than the bone of the jaw with which it may be intimately co-ossified, and is admirably adapted to sustain the crowns of the teeth, both as regards its organic and its physical functions. The teeth of *Mosasaurus* belonging to the functional series or those in use, were succeeded by a new set which underwent their development at the postero-internal portion of the alveoli occupied by the former. For the reception of the growing crowns of the new teeth the fangs of the functional series were gradually excavated, through absorption of their structure, in a direction from within obliquely outward and forward, upward and downward. At first the inner parapet of the jaw slightly contributed to the parietes of the cavity for the new tooth, but with this trifling exception it was through excavation of the contiguous fang of the functional tooth that the former was accommodated. In the progress of the excavation, the pulp cavity of the functional tooth became exposed and then cut off from communication with the nerves and blood-vessels which supplied its contained pulp. The fossil specimens further indicate that it was during the progress of the excavation of the fangs of the functional teeth that these became co-ossified with their alveoli, as if to resist a tendency to expulsion from the jaw. The cavities for the new teeth in the fossils are ovoid in form and open at the postero-internal part of the extra-alveolar portion of the base of the fangs of the functional teeth; and from the opening the apex is seen protruding. After the development of the crown of the new tooth the fang was produced, and the increase gradually became so great at the next step as to have converted the fang of the old tooth into a large capsule, surmounted by its crown still in use. With the advance of growth of the new tooth the crown of the old one became so enfeebled in its connection with its excavated fang as readily to be broken off by external violence, or to be displaced by the continual growth of the fang and protrusion of the crown of the new tooth. The fang of the latter continued its growth within a mere cylinder of the fang of the old tooth until its crown was made to assume a position in the functional series. The development of the new tooth was scarcely completed before a successor commenced the same process, and thus one tooth was followed by another throughout the life of the animal, as in recent reptiles. Some of the fossil specimens show that not unfrequently, while a successional tooth occupied a cavity within the fang of its predecessor it was accompanied by another, situated behind the former. For the accommodation of the second successor a cavity was produced not only at the expense of the fang occupied by the first one, but partly at the expense of the alveolar partition and fore part of the functional tooth behind. The pulp cavity of the teeth of *Mosasaurus* varied in size according to the period of development and age of the teeth, but all the fossil specimens I have seen indicate that it was absent at no period. I have never seen a solid tooth of the American *Mosasaurus*, contrary to the statement of Cuvier in regard to the Maestricht Monitor, that the teeth are only hollow during their development and are most frequently found entirely solid. Nor does the large size of the pulp cavity in the mature teeth warrant the term of pleodont applied to the *Mosasaurus* by Owen. In the shedding of the crowns of the teeth of *Mosasaurus* they appear generally to have been detached from their excavated fangs a couple of lines from the enamel border. In several fossil specimens the base of the shed crowns is excavated in a conical or lenticular manner from the periphery to the central remnant of the pulp cavity. The peripheral border varies from a thin sharp edge to a fractured one of a couple of lines in thickness. The remnant of the pulp cavity, where it communicates with the excavation, is about a third of the diameter of the crown, and from one-third to one-half its length. The alveoli generally appear to be completely separated in the ordinary manner among most animals by thin osseous alveoli. In those instances in which there were two nearly contemporaneous successors to a tooth in use, the crowding to accommodate the former appears to have been such that the alveolar partition was obliterated, and was subsequently replaced by the cylindrical remains of the fangs which were excavated for the successional teeth." He then proceeds to describe in detail the various teeth which had passed through his hands, and which had been obtained from various localities in the United States. All the specimens are dug out of strata, usually the greensands, forming portions of the upper, or newer cretaceous group. The age, indeed, seems to be very nearly identical with that of the European relics belonging to this genus. The range of the genus must have been considerable, for some bones were obtained by Chandler from the earth forming the banks of the river Purûs in Brazil.

(Leidy, *Cretaceous Reptiles of the United States*, 1865.)

MOSCHIDÆ [E. C. vol. iii. col. 903—907]. The popular name of musk-deer, which has been given to the members of this family, expresses a truth which has been already dwelt upon in the E. C. a little. This truth is, that in many respects they resemble the deer. This resemblance is, however, not so close as might be supposed from Dr. Gray's statement in 1836, that the genus *Moschus* of Linnæus (whose definition would include all the members of the modern family *Moschidæ*), differs from *Cervus* in one character only, viz., in having no horns. This remark was perhaps intended to apply to Linnæus's generic definition, and not to imply that *Moschus* and *Cervus* are identical in every character of generic importance, with the exception of the horns. In the sequel we shall have occasion to allude to several important differences between the deer and the musk-deer; but we wish the reader to bear in mind that although the differential points will chiefly engage our attention, there are numerous peculiarities in which the two groups agree.

A second feature in which the present article will present important modifications of the views enunciated in the former one has reference to *Tragulus*. A third feature is the account of the genus *Hyomoschus*. And a fourth is the palæontology of the group.

The *Moschidæ* form what is called an aberrant group. It is difficult to define precisely what is meant by the term aberrant, but it seems to imply something that does not harmonise with what is thought to be the general plan of nature. Thus the *Moschidæ* are like deer, and yet they cannot be classified with them, in consequence of deviations in their structure which approximate them to the camels, say some, and to the pigs amongst *Pachydermata*, say others. Aberrant groups, in most cases, have a more generalized structure than the most flourishing existing families to which they are nearest allied, and hence it frequently happens that such groups seem to belong to several families, or to find their most natural position at the extreme limits of one or two families. Hence it is that classifiers are so frequently unsettled as to the correct places which should be assigned to such groups. When aberrant groups have been carefully and fully studied, it almost always happens that they are found to be those which commenced their existence at an early period of the prevalence of the order, that a few, or many, of the nearest allied genera or families have passed out of existence, and that they are represented by a small number of species which seem, to those who confine their attention to living forms, as though they were out of place in the present fauna; whereas to those who study both the living and extinct forms, they appear to be antiquated, but not anomalous.

The last monographer of the group, M. Alphonse Milne-Edwards, prefers to divide it into two families, the *Tragulidæ* and the *Moschidæ*. In his opinion it comprises three genera, viz., *Moschus*, *Tragulus*, and *Hyomoschus*, and we shall follow him. Before, however, entering into details, it will be as well to give his synopsis. The position of the group will be gathered from the annexed arrangement of the *Ruminantia* in two sub-orders. The first sub-order, *Phalangigrada*, comprises one family only, the *Camelidæ*. The second sub-order, *Unguligrada*, includes the families *Girafidæ*, *Bovidæ*, *Capridæ*, *Antilopidæ*, *Cervidæ*, *Moschidæ*, and *Tragulidæ*.

MOSCHIDÆ.

Polycotyledonal placenta. No appendages to the forehead. Dental formula:—

$$\text{Incisors, } \frac{0-0}{4-4}\text{; canines, } \frac{1-1}{0-0}\text{; molars, } \frac{6-6}{6-6}$$

Canines largely developed in the male; incisors in a continuous series, similar, and spatuliform. Stomachs four in number. Males provided with musk secreting glands.

Moschus.—This is the only genus and comprises but one species, *M. moschiferus*.

TRAGULIDÆ.

Placenta diffused. No frontal appendages. Dental formula:—

$$\text{Incisors, } \frac{0-0}{4-4}\text{; canines, } \frac{1-1}{0-0}\text{; molars, } \frac{6-6}{6-6}$$

Canines well developed in the males; incisors arranged in an interrupted series, the middle ones being much wider and flatter than the others. Stomachs three in number. Musk secreting glands not present in males.

Tragulus.—As used by the early zoologists, this name was synonymous with *Moschus*; but in 1843 Dr. Gray applied it to a section of the Linnæan genus *Moschus*, and it is in this restricted sense that it is now employed. Milne-Edwards defines it as having the middle metacarpal and metatarsal bones co-ossified into one canon bone; the lateral digits well developed, and nearly co-equal with the canon bone; and the inter-maxillary bones united with the nasals.

T. javanicus, Pallas.—Size small. The general colour is fulvous, mingled with black on the back and red on the flanks. The neck is gray; the throat is marked with three white bands, separated by gray interspaces. The head is black above, which tint is continued backwardly along the nape of the neck. The tail is moderately long, brown on the upper, and white on the lower side, the last mentioned colour also prevailing at the extremity. The metatarsus is bald on its posterior surface, as also is the space between the lower maxillaries behind the chin.

T. napu, Raffles.—Size considerable. Colour fulvous, mingled with black. Head, nape, and back darker than the rest of the body. Throat marked with five white bands, one of which is median, and four lateral; of the four two are extensive, and situated low down, while the other two are small, and stretch along the maxillaries. The space between the large bands is almost black; and a dark line runs from the eye to the nostrils. The tail is of moderate length, fulvous on the upper side, and white on the under side as well as at the extremity. Metatarsi bare behind. A bald patch is situated at the angle of the maxillary, just behind the chin.

T. Kanchil, Raffles.—Size small. Feet high. Colour of a deep reddish hue on the upper portions of the body; middle and upper parts of the neck marked with a well-defined black band. Throat longitudinally barred with three white bands, with interspaces of the same colour as on the sides of the neck. Tail moderate in length, brown above, but white below and at the tip. Metatarsus bare behind. The maxillary angle behind the chin is also bald.

T. Stanleyanus, Gray.—Size medium as regards the other species of the genus. Colour bright red, modified by black on the back and on the upper portions of the neck; the sides of the neck, as well as the flanks of the body, are red. Throat marked with five white bands, of which the two uppermost are the smallest; the interspaces have the same colour as the neck. The jaws are red; and the head is more or less tinted with red on the upper portions. The tail is of moderate length, white on the under side, as also at the tip, and red above. The hinder face of metatarsus is bald. The inter-maxillary space behind the chin is also bald.

T. meminna.—Size medium. Body ornamented with white spots and bands. The general colour is fulvous, the tint being darkest on the head and upper portions. The neck has five white bands, of which the uppermost lateral pair are very long, and the lower two much shorter than in the foregoing species; the interspaces correspond in colour with the sides of the neck. Tail very short; fulvous above, and white below and at the extremity. Hinder face of metatarsus covered with hair, and the intermaxillary space behind the chin is also covered with hair.

Hyomoschus, Gray.—Median metacarpal bones distinct at all ages. The metatarsal bones are first isolated, and subsequently united to the canon bone. The lateral digits are well developed, of robust proportions, and co-extensive with the middle digits. The inter-maxillaries are never connected with the nasal.

H. aquaticus, Ogilby. Body heavy in proportions, long, and low on the legs, of a brown colour, and marked on the flanks with spots and bars of white. Throat ornamented with five longitudinal bands, of which the two upper lateral ones are very long; the interspaces between them have the same colour as the sides of the neck. Tail moderately long, brown above, white below and at the tip. Hinder surface of metatarsus, and the submental maxillary angular space, covered with hair.

H. crassus, Lartet. This is the only extinct species definitely recognised.

The musk-deer, or *Moschus moschiferus*, is like certain deer, but with far less slenderness of build, and with shorter legs. The head is small and short, and the muzzle is pointed and naked. The tail is very short, thick, conical, and smooth. In males of two years old and upwards it is bare and red; but in young males and in females of every age it is hairy on the upper and woolly on the under side. The hinder limbs are much longer and far more robust than the fore; and this remark applies as well to the muscular as to the osseous parts; an arrangement which is manifestly correlated with the usual clambering habits of these creatures. As has been mentioned in the E. C., each hair is variegated in tint; and as these are of varying lengths and are differently disposed in various parts of the body, the differences of tint in those places are more or less due to the mechanical arrangement of the hairs. Independent of this there are variations of colour connected in some way with the age or growth of the individual, since the young differ somewhat from the adults. According to Milne-Edwards, whose statements are based upon the observations of Pallas, the young have the head brown above, and grayish on the jaws; the edge of the upper lip as well as underneath the chin is whitish; from the chin two diverging white lines proceed towards the angle of the jaw; on the hyoidean region is another white patch, which is separated from that under the chin by a lateral gray band, and which is prolonged on each side towards the ear, at the base of which is a tuft of whitish gray hairs. The hinder margin of this light collar is marked by some hairs of a darker tint than those on the contiguous parts of the neck, which form the commencement of a brown band that runs along the fore-part of the neck, and between the fore-limbs underneath the chest. On either side of this dark median band is a whitish line, which commences a slight distance from the above-mentioned collar along the breast, and for a considerable distance down the inner aspect of the fore-leg. The upper portion of the body, the flanks, and the outer sides of the limbs have a general reddish hue mingled with gray. The sides and hinder portion of the back are spotted with ill-defined dapplings of gray. The spots are arranged in rows, and are larger on the back than on the flanks; and towards the umbilical region they become whiter. As the individual advances in age the differentiation of colouring becomes less marked, but the degree to which it is obliterated seems to be an individual character. Some adults retain the livery in a far less altered state than others. Thus one adult specimen from Nepaul examined by Pallas had numerous spots, while another individual, an old male, from some of the mountains of the contiguous countries, was of a uniform dark brown tint, without any traces of spots or of the white bands on the front part of the neck, and with faint indications only of a grayish collar on the upper part of the neck. Numerous other slight modifications of colouring have been observed, which, like those mentioned above, have been regarded as the distinctive marks of so many species. Milne-Edwards believes that there are no sufficient grounds for regarding them as distinctive specific characters, and that at most they constitute the varieties of one and the same species. He recognises four varieties, which he names *maculata*, *vittata* (which we suppose is the correct rendering of *rubanée*), *concolor*, and *leucogaster*. He has no doubt many other varieties will be discovered when the animals are more closely studied in their native haunts.

The general colouring of the adults of the several species of *Tragulus* has already been given in the synopsis; but it may here be mentioned that Milne-Edwards decides that *T. javanicus* is not the same as *T. napu*, as maintained by Bennett; and that the description given in the E. C. applies to *T. napu*. With respect to the colouring of the young a few words may be given. In *T. javanicus* the young has the same colouring and markings as the adult; and a similar remark applies to *T. napu*. In *T. Kanchil* the young have the under side of the belly of a reddish tint, which tint is gradually changed to white in the adult. Dr. Gray recognised three species based upon specimens of *T. Kanchil* of different ages. The young with the russet belly were designated *T. fulviventer*; those somewhat older, in which this tint was retained along a central band, were called *T. intermedius*; while *T. Kanchil* was retained for the white-bellied individuals. Dr. Gray has himself recognised that these characters are simply variations on the specific type. His mistake teaches us the lesson that it is premature to assign classificatory values to differences before the life history of the species in question or those of closely allied species have been traced out. In *T. Stanleyanus* the individuals present considerable variations in colouring according to age. In one specimen, four months old, the stomach was uniformly ruddy, without any intermixture of black; the breast was white; the small lateral bands on the throat were well defined, but the others were very obscure. As growth proceeds the russet hairs are replaced by white, but it frequently happens that the change is not completed in mature individuals. The adults also present many variations of colouring amongst themselves. *T. meminna* also presents considerable variations in tints, which are partly due to sexual differences and partly to age.

These few facts point to certain general conclusions. In some species the colouring varies little both as regards the adults amongst themselves, and the individuals at different ages; in others the variation is slight; and yet in others it is considerable, the variation amongst the adults being roughly proportioned to the extent of modification which is undergone by the individual. Why one species should vary in the same group of characters which are constant in another is a problem for future inquirers to solve.

Differences of an analogous kind are met with in all other parts of the structure. In *Moschus* the skull is long and narrow; the cavity for the brain is of small extent as compared with the bones of the face, that is, those which immediately protect the sense-organs. The forehead is low, and almost on the same level as the nose, whereas in stags and antelopes this part is far larger proportionally, and raised considerably above the backwardly-produced plane of the nose. When the skull is in the horizontal position, this plane inclines upward at a small angle from before to behind. The super-occipital bone slopes slightly downwards at the hindermost portion of the upper surface of the skull in *Moschus*, and consequently adds to the length of the head; whereas in nearly all *Cervidæ* and *Antilopidæ* it contributes to the vertical back surface of the cranium. The occipital foramen is large, but the condyles are small, nearly vertical in position, and closely approximated; whereas in the stags and antelopes the condyles are widely separated. The parietal bones are well developed, and the parietal crest which forms the upper border of the temporal fossæ is distinct, and is continuous with the external occipital crests, which are prolonged to the margins of the mastoid apophyses. At the lower edge of the hinder portion of the parietals are some vascular foramina, which are frequent amongst *Cervidæ*, but rare amongst the antelopes. The temporal bones are of moderate size, and the temporal depressions are deep and large. The ear aperture is small, and is separated from the spring of the zygomatic arch by a deep oval depression for the reception of certain nerves and vessels; it is analogous to the cavity occupying a like position in *Cervidæ*, *Antilopidæ*, and *Bovidæ*. The petrotympanic bone forms a small prominence with thick and rough walls; but in *Tragulus* and most *Cervidæ* the prominence is large and the walls are thin. The frontal bone has on either side a longitudinally disposed depression just above the superciliary arch, which depression continues into a superficial groove, which extends as far as the lachrymal bone. In the valley thus formed is a linear series of suborbital foramina, an arrangement which is frequent in *Cervidæ;* although in a few species of the last-mentioned family only one or two such foramina are present. The anterior edge of the frontal is deeply emarginated for the reception of the nasal bones, but not so much so as in the *Cervidæ* and *Antilopidæ*. The nasal bones are narrow, long, uniform in width, nearly horizontally disposed, and extend well beyond the insertion of the canine. In the *Cervidæ* the relative length is far less; and in the *Antilopidæ* the nasals are remarkably short. Amongst the *Cervidæ* the muntjac comes nearest to the present genus, and in it the nasals reach the level of the canine; in many other species they stop short of this point; and in the moose-deer, as also in the camels, they fall far short of it. The lachrymal is large, and fits into a groove of the maxillary; it is flat, and without the depression which lodges the tear-glands in most of the *Cervidæ* and *Antilopidæ*. There is only one lachrymal foramen, which is placed at the lower side of the bone, and close to the orbital margin, an arrangement which is the exception amongst *Cervidæ*, and the rule amongst antelopes. Its anterior margin is articulated with the frontal; and it is separated from the nasal by the backward continuation of the maxillary, as far as the frontal. The maxillary bone is very large, and deeply excavated for holding the enormously-developed canine. It is penetrated by the suborbital foramen just above the fore edge of the first molar. The intermaxillary bones, the nasal apertures, and the incisive foramina, are broad. The position of the posterior orifices of the nose varies according to age and idiosyncrasy; in most ruminants they are narrow, and never exceed half the length of the hinder margin of the palatine arch; in *Moschus* the middle portion of the palatine bone, which forms the anterior margin of the internal nasal apertures, does not terminate, as is usually the case, on a line with the adjacent margin of the pterygoid fossæ, but is continued backward so as to contribute more or less to the osseous arch between these two fossæ. This peculiarity is more marked in young individuals than in adults, but it never becomes so conspicuous as in *Tragulus*. The lower jaw is similar to that of the *Cervidæ*, more especially as regards the great extent of the diastema, the well-defined angle of the jaw, the small size and shape of the condyles, and the broad lamellar subfalcate and high coronoid. The mentary foramen is single, and concealed by the canine when the mouth is closed, while a little farther back, but on a slightly higher level, is a nutritive foramen. The dental system is, in general features, like that of most ruminants. The lower incisors are eight in number, similar in form, but gradually diminishing in size from the first to the fourth on each side. The median are closely contiguous, spatula-shaped, as in deer and antelopes, and with a rounded trenchant margin. Professor Owen is of opinion that the outermost pair are really canines, as is always indicated by the lateness of their development, and frequently by some peculiarity of form; but Milne-Edwards demurs to this view. Such a question as is above indicated would be at once settled by following out the development of the dental system. The upper canines form one of the most prominent peculiarities of the musk-deer, but care is required not to confound the conspicuousness with the importance of a character. In no other ruminant are these canines so long as in *Moschus moschiferus*, and although the upper canines are placed in the first rank as distinctive marks of difference from the *Cervidæ*, yet there are many phenomena connected with these teeth which indicate the relationship between these two groups. In all *Cervidæ*, and in nearly all ruminants, the upper canines are larger in the males than in the females, and this is conspicuously the case in *Moschus*, in which the tusks of the male often project beyond the lip for more than two inches, whereas in the young and in the adult females they are not perceptible externally. Amongst the *Cervidæ* the muntjac has exserted canines, but they do not approach the dimensions of those of *Moschus*, but, as in that genus, they are confined to the adult males. Professor Owen notices that there is a remarkable relation between the developments of the canines and the horns, the former being large when the latter are small, and *vice versâ*, as though there were some functional connection between the two. As these parts seem to be subject to the same general laws in both groups, and present, even amongst living species, a marked graduation of development, one might almost expect to discover extinct species which would fill up the gap between the *Cervidæ* and *Moschidæ*. One such form seems to be presented by *Dremotherium* of miocene times, which had canines almost as large as *Moschus*, and which, we may conjecture, had the horns either absent or of small size. The molars are six in number, as in all ruminants, the permanent set consisting of premolars 2, 3, and 4, and of the true molars 1, 2, 3. In character they most resemble those of *Cervidæ*, but they present some minor differences therefrom.

We will next turn to the skull of *Tragulus*. In general form it resembles that of *Moschus*, but is by no means identical therewith. Thus in *Moschus moschiferus* the contour of the upper surface, from a lateral point of view, is as follows: the margin of the nasal aperture slopes upward from the incisors at an angle of about 40°; then commencing from the anterior end of the nasals, the slope is about 20° to a little behind the orbit, and from this last point there is a downward slope of about 25°. In *Tragulus napu* the margin of the nasal aperture slopes upward at an angle of nearly 70°; from the anterior end of the nasal to the middle of the upper border of the orbit the inclination upwardly is nearly 40°; from this it runs nearly even to a level with the hinder margin of the lower jaw, and then declines nearly 20° to the back of the skull. In *T. Kanchil* there is the same upward inclination of the margin of the nasal aperture as in *T. napu;* but from thence there is a general slope, modified by slight undulations, and by a slight prominence over the orbital region, of about 30° to a point on a line with the posterior angle of the lower jaw; and from this point there is a declination of about 15°. In *T. meminna* the margin of the nasal aperture makes an angle of about 65°; then there is an even slope of 25° to a point a little behind the orbit; from whence there is a declination of about 20°. In *Hyomoschus*, as will presently be indicated, the contour of the upper surface of the skull is more depressed than in any of the preceding species. As may have been noticed, the contour of the skull of *T. napu* is modified by the prominence of the upper margin of the orbit. This margin is somewhat lower in *Moschus*, being almost level with the margin of the upper surface of the skull; in *T. Kanchil* it is somewhat lower still; while in *T. meminna* it is much lower. The greatest height of the skull, by which we mean both cranium and lower jaw, is in the vertical plane descending from where the upward inclination of the cranium terminates, to the under angle of the lower jaw; and the length of the skull is 2¼ times greater than the height. In *T. napu* the greatest height is from the middle of the orbit, and by the anterior end of the true molar 3 to the base of the lower jaw. The length of the skull is barely twice the height. In *T. Kanchil* the plane of greatest height is situated at almost the same corresponding position as in *Moschus*. The length is far short of twice the height, the deficiency being about one-sixth of the latter dimension. In *T. meminna* the point of greatest height is similarly situated as in *T. napu*, the modification being due to the downward curvature of the under side of the lower jaw. The relation between height and length is the same as in the last species. The greater relative length of the skull in *Moschus* than in *Tragulus* is also shown in the proportion between the line from the incisors to the fore part of the orbit, and from the latter point to the back of the skull. In *Moschus* the former exceeds the latter; in *Tragulus* the former is shorter than the latter. In connection with this may be noticed the great extent of the diastema in *Moschus* as compared with what it is in *Tragalus*. In *Moschus* the distance from the foremost incisor to the commencement of the molar series, is equal to the extent of the molar series itself, and these parts together occupy three-fourths of the lower jaw. In *T. napu* the molars occupy almost twice as much space as the distance from the first incisor to the first molar; and the same remark applies to *T. Kanchil*. In *T. meminna* the molars occupy nearly two and a half times the space from the foremost molar to the front incisors. The backward extension of the molar series also presents differences. In *Moschus* the hindermost molar is in a line with the middle of the orbit; in *Tragulus napu* and *T. Kanchil* it extends to the posterior hird; but in *T. meminna* it is situated almost in a line with the hinder margin of the orbit. The parietals are well developed, and approach much nearer to the orbits than in *Moschus* and in most ruminants. The frontal is long, narrow, and extends beyond the orbit, and to a line with the suborbital foramen. The articulating margin of the frontal with the nasal is straight, and not emarginated as in *Moschus* and most ruminants. There is only one suborbital aperture. The temporal fossæ are smaller and shallower than those of *Moschus*, and do not reach so high up towards the sinciput as in *Moschus* and the *Cervidæ* generally. The ear aperture is small, and situated immediately below the zygomatic arch, there being no hiatus as in *Moschus*, *Cervidæ*, and *Antilopidæ*. The petrotympanic bones are usually prominent, and form large tuberosities on either side of the basal portion of the occipital bones. This differs much from what occurs in *Moschus*, but comes nearer to the development of the same parts in some of the African antelopes, in the *Rucervus Duvaucellii* of India, and in the *Rusa equina* of Sumatra. The lachrymals are much larger than in *Moschus*, usually of a quadrilateral form, and unite with the frontals by the whole of their upper margins. These bones have no depressions for the tear glands, a feature in which this genus agrees with *Moschus* and differs from *Cervidæ*. There is no foramen at the junction of the lachrymal, frontal, nasal and maxillary bones, in which respect it differs from *Moschus*, the *Cervidæ*, and most antelopes. In *Moschus*, the fore margin of the orbit is in a line with the fifth molar; while in *Tragulus* it is advanced nearly as far as the third molar. The palatine foramen is formed entirely in the palatine bone, and the middle portions of the palatines are so produced as to push the hinder nostrils very much backward, and to convert the posterior portion of the nasal cavity into a tube, the orifice of which is widely separated from the anterior edge of the pterygoid fossæ. The coronoid process is very small, and when the mouth is closed projects but little above the zygomatic arch, a character which enables us readily to distinguish the skull of *Tragulus* from *Moschus* and all ruminants, and one which seems to connect this family, although distantly, with the *Suidæ*. In the dental system it may be noticed that the eight incisors form a discontinuous series, there being a considerable gap between the middle pair, and that there is an appreciable difference in the shape of the several pairs. The canines are large in the males, but are by no means so highly developed as in *Moschus;* and, moreover, their shape does not correspond with those of the genus named. The three true molars, and the first premolars on each side of the upper jaw, do not present any great difference from the corresponding teeth of *Moschus*, but the two front premolars do present striking differences. The form of the three premolars of the lower jaw differentiates *Tragulus* from all ruminants except *Hyomoschus*.

The great disproportion in the length of the fore and hind limbs of *Moschus* is associated with other differences of a more marked kind in the osseous structure of the limbs. Thus the canon bone of the fore-limb is much shorter than that of the hind-leg. In the fore-limb the false hoofs, or external digits, are articulated with the sesamoid bone. The first phalanx is very short, and is provided with an extensive but obliquely disposed articular facet; the second phalanx is robust in form; and the third is long. There is no trace of any lateral metatarsal bone. The lateral digits of the fore limb are also of considerable length, but they are articulated, not with the sesamoid, but with a small conical metacarpal bone, which is attached to the canon bone by stout ligaments for more than two-fifths of the length of the latter.

In *Tragulus* the metacarpus is formed of a short and stout canon bone, formed by the union of the two median metacarpals, and of two lateral bones, which represented other two metacarpals. The dual nature of the canon bone is indicated by its compressed form, combined with the presence of a deep median groove. The structure of the lower articular surface of the canon bone differs from that met with in *Moschus* and ruminants generally, and approaches that presented in *Cainotherium* and *Suidæ*. The lateral metacarpals are solidly connected with the canon bones, and are almost co-equal in length therewith. The lateral digits are shorter than in *Moschus*, and do not extend farther than the middle of the first phalanx of the median digits. The metatarsal is also formed of a canon bone composed of two metatarsals soldered together, and of two lateral metatarsals, one of which, usually the outermost, is frequently ossified more or less with the canon, especially in old individuals. In the annexed table we have brought together the dimensions of the various parts of the animal and skeleton in the species of *Tragulus*, from which may be gathered their absolute sizes and relative proportions. The metre is retained as in the original, and is equal to 39·37 English inches. Column 1 appertains to *Tragulus javanicus;* column 2 to *T. napu;* column 3 to *T. Kanchil;* column 4 to *T. Stanleyanus;* column 5 to *T. meminna;* and column 6 to *Hyomoschus aquaticus*. All the measurements relate to the males, except in the case of *T. Stanleyanus* :—

	1	2	3	4	5	6
	metre.	metre.	metre.	metre.	metre.	metre.
Length of body.	·49	·57	·42	·485	·55	
head	·10	·12	·08	·115	·12	
neck	·09	·10	·09	·100	·07	
Height at withers	·21	·26	·21	·230	·24	
rump	·23	·28	·23	·250	·30	
Length of tail	·075	·085	·075	·070	·02	
anterior canon.	·039	·045	·041	·041	·035	·041
posterior canon.	·059	·069	·065	·062	·056	·062
radius	·056	·069	·058	·062	·055	·080
cubitus	·070	·086	·070	·078	·072	·098
humerus	·068	·080	·068	·075	·074	·110
calcaneum	·026	·037	·024	·030	·027	·044
tibia	·093	·110	·095	·102	·099	·130
rotula	·020	·027	—	·026	·021	·033
femur	·081	·100	—	·097	·086	·136
pelvis	·086	·120	—	·105	·105	·173
skull	·095	·115	·089	·110	·100	·143
from the extremity of the muzzle to the first upper molar	·025	·034	·023	·030	·021	·035
from the first to the last molar	·032	·040	·030	·038	·042	·050
of lower jaw	·075	·094	·070	·088	·081	·113
lower molar series	·038	·045	·034	·043	·047	·060
first anterior phalanx	·009	·013	·009	·011	·010	·014
second do.	·006	·008	·006	·006	·007	·010
first posterior phalanx	·014	·020	·012	·016	·013	·015
second do.	·009	·012	·007	·008	·009	·011
canine	·014	·022	·012	·003	·017	·030
Circumference of posterior canon in the middle	·017	·024	·016	·018	·018	
of anterior canon.	·016	·020	·014	·016	·017	

Hyomoschus is more like *Tragulus* than *Moschus*, but it differs from the latter genus to a greater extent than *Tragulus* does. The upper contour is remarkably flat; thus the angle formed by the line joining the anterior end of the premaxillary and nasal and the horizontal basis of the skull is barely 20°; the slope from the nasal bone to a point in a line with the middle of the orbit is about 15°; and from the last place to the back of the skull the slope downwards is on the average not more than 10°. The greatest height is where a vertical plane passes through where the upward and downward slopes, already mentioned, unite at the summit of the cranium; and the length of the skull is more than twice its height. The diastema is moderate in length, but the molars occupy a considerable space, or more than half the length of the lower jaw. The parietal crests are slightly developed in young individuals, but are very prominent in adult males. The petrotympanic bone is more prominent even than in *Tragulus*. The intermaxillary bones are short, united with the maxillaries, but are not prolonged so far as the nasals, as is the case in *Moschus* and *Tragulus*. The coronoid process is small, as in *Tragulus*. The teeth generally resemble those of the last-mentioned genus, but the molars are more mammillated, and so far they come nearer to the type of form which occurs in some *Pachydermata*. The upper canines are large, exceeding those of *Tragulus*, but falling considerably short of those of *Moschus*.

As regards the visceral organs *Moschus* approaches the *Cervidæ* more closely than the other genera. As in most ruminants the stomach of *Moschus* is divisible into four portions known to anatomists by the special names of *rumen*, or *paunch*, *reticulum*, *psalterium*, and *abomasus*. In *Tragulus* the stomach is simpler, and it is conjecturally probable that *Hyomoschus* has as simple, and perhaps a simpler, stomach than *Tragulus*. Professor Milne-Edwards gives a full description of the stomach of *Tragulus*, and Professor Owen a somewhat shorter one; the following description is that by the last-named authority:—"In a pigmy musk-deer (*Tragulus Kanchil*) the paunch is of a sub-globular form, partially divided into three chambers by the folding inwards of the parietes, forming prominent ridges; the inner surface is beset with filamentary villi, covered by dense epithelium. The second cavity or reticulum is less distinctly separated from the rumen than usual; the cells are very shallow and are lined by dense epithelium. The passage leading from the œsophagus to the third cavity is bounded by two low parallel ridges: the longitudinal lamellæ which are characteristic of this cavity in other ruminants are wanting, but as it possesses the dense epithelium it may be regarded as a rudimentary form of psalterium; it is partially separated from the fourth cavity by a semilunar fold. This cavity has a smooth gastro-mucous membrane; the muscular tunic is thickest at the pyloric end, where a small valvular protuberance projects above the orifice leading to the intestine. This least complex condition of the true ruminant stomach represents a stage in its development in the larger species." Milne-Edwards agrees with Owen in the greater simplicity of the stomach of this species relatively to that of other genera of the *Ruminantia*, but he differs from him in regard to the extent of the simplicity. He says that the individuals dissected by him belonging to *T. javanicus*, *T. Stanleyanus*, *T. Kanchil*, and *T. meminna*, had no trace whatever of the third division of the stomach or *psalterium*, and that the statements of former zoologists asserting the existence of this part in the musk-deer group have been based upon the examination of individuals which do not belong to it, but to the *Cervidæ* or *Antilopidæ*. This observation will not apply to Professor Owen's description, since *T. Kanchil* is admitted to belong to the musk-deer group; the explanation in this case seems to be that Professor Owen regards certain appearances as the rudiments of *psalterium*, which have not been regarded as such by Milne-Edwards. The two authorities above mentioned have remarks on the liver, the brain, and other organs, but those who wish such details must consult their works; passing by these we will notice Milne-Edwards' views as to the affinities of the *Moschidæ* in the older and wider sense of that term. He says it does not form a natural group as usually supposed, a view which was first proposed by M. Pucheran, who separated *Tragulus* from *Moschus* on account of the wide differences in the structure of their viscera, more especially of the stomach. These differences he thought were sufficient to warrant the establishment of two families, viz., the *Tragulidæ* and *Moschidæ*, a view which had been rejected by almost all subsequent anatomists previous to Milne-Edwards adopting it. The absence of horns and the large development of the canines have induced some to place the musk-deer in the same division as the camels, but this grouping cannot be admitted. The *Camelidæ* form a distinct family from all other ruminants, being differentiated from them by organic distinctions of great importance, such as the elliptical form of the blood globules, the structure of the stomach, the arrangement of the teeth, and the formation of the feet. This view is expressed in the synopsis previously given; from which it will also be seen that the musk-deer are arranged along with the other ruminants. The camels walk on their fingers; but all the other families walk on the tips of their toes. The *Moschidæ* (in the narrow sense) agree with the *Cervidæ* in the form of the placenta, and in the general plan of structure of the brain, stomach, and skeleton. The absence of horns is not a character of so much classificatory importance as might at first be supposed. In some species of *Cervidæ* horns are present in both sexes; in others the females want them; and in others they are rudimentary. Hence their absence in *Moschidæ* may be looked upon as due to their development having stopped short of that stage at which these appendages are produced. Both groups belong to the same type, which is more fully developed in *Cervidæ* than in *Moschidæ*. As has already been noticed, the large upper canines do not serve to absolutely divide the *Cervidæ* from the *Moschidæ*. The principal distinctive anatomical character is the musk gland, but this is a sexual peculiarity. The differences which separate the *Moschidæ* from the *Tragulidæ* are more numerous and significant. The *Tragulidæ* are separable from the *Moschidæ* and all ordinary ruminants, by the structure of the placenta, a character which approximates them to the *Camelidæ*, the *Solidungula*, or horse group, and the *Omnivora*, or hog group. The stomach of *Tragulidæ* differs from that of *Moschidæ*, and all other unguligrade ruminants in the way above described. The blood globules of the *Moschidæ* are not known, but those of the *Tragulidæ* are at once distinguishable from those of all other ruminants, so far as examination has proceeded, by their excessive minuteness. The *Tragulidæ* differ from all other families of the *Ruminantia* by their complete lateral metatarsal and metacarpal bones; by the union of the cubo-scaphoid with the cuneiform bone; and by the simpler character of the brain. They further differ from *Moschidæ* in wanting the musk gland. The *Tragulidæ* apparently connect the ruminants with some of the pachyderm families. This is most marked in the resemblance between *Hyomoschus* and *Cainotherium*.

The distribution of *Moschus* is far more extensive than Pennant was aware of. Its head-quarters is probably the highlands of Central Asia; and from this centre it spreads out over nearly the whole of Asia. In places it is known to occur north of the arctic circle. It has been recognised in the neighbourhood of the sea of Okhotsk, in the mountain ranges of China, and on the south-east coast of Cochin China. In the west it frequents the basins of the Irtish and Obi, Mongolia, Thibet, Kashmir, and Nepaul. Roughly stated, the known area of distribution extends from 70° to 170° E. long., and from 65° to 15° N. lat., which may be estimated at about two million square English miles. The individuals are not uniformly dispersed, but are most aggregated in the most mountainous districts, so that even in the most southern portions of the area they live in a temperate or cold climate. *Tragulus* is adapted for, or at any rate exists in, a warmer atmosphere than *Moschus*, and occupies all the portion of Asia south of that frequented by that genus. In a few places the two genera are found on the same area, but in such cases the *Moschus* inhabits the mountains, and the species of *Tragulus* dwell in the lower land; so that, as far as has been ascertained, individuals of the two groups have never been seen at the same moment of time when in their native haunts. The species have very restricted areas, and in no case will such areas compare with that of the far-ranging *Moschus moschiferus*. The head-quarters of this genus seems to be the south-eastern islands of the Malay Archipelago. *T. Kanchil* encroaches more nearly on the domain of *Moschus* than any other species. It has been obtained from Camboja, Siam, the Malay peninsula, Poulo-Penang, Borneo, and Java. *T. javanicus* is also resident in Poulo-Penang, Java, and a few other neighbouring islands of the Malay Archipelago. *T. napu* is only known from Sumatra, from which island the two previously mentioned species would seem to be absent; but as this region of the globe has been insufficiently explored, our knowledge of the distribution of each species is liable to be materially modified by future researches. *T. Stanleyanus* has nearly the same distribution as the foregoing; but with a more westward extension, since specimens have been obtained from India and Ceylon. *T. meminna* carries on the generic area so as to connect it with the western range of *Moschus* in the same way that *T. Kanchil* forms the connection on the east. *T. meminna* is abundant in Ceylon: and is less common in Southern India, and there are faint indications that it ranges as far north as Nepaul. The other forms of the musk-deer group are widely separate from the main family area. *Hyomoschus aquaticus* is known only at Sierra Leone, on the west coast of Africa, and *H. crassus* is as yet confined to the miocene strata of France. The existence of these two species in the same parallel, viz., about 5° E. long., but separated by 40° of latitude and an immense interval of time, and far away from their nearest allies in Asia, permit us to infer that other species of the same family will be discovered in the intermediate areas, at present without representatives, either living or extinct within the tertiary epoch. It is not unlikely that some of the deer-like osseous fragments already stored in our museums may prove to belong to the present group, such, for instance, as those assigned to the *Dremotherium* of E. Geoffroy St. Hilaire; the *Amphitragulus* of Pomel, the *Dorcatherium* of Kaup, and a few other genera, founded, like the above, on fossil bones.

(Milne-Edwards, *Annales des Sciences Naturelles*, 5th Série, tome ii. pp. 49—167; Owen, *On the Anatomy of Vertebrates*, vols. ii. and iii.)

MYTILIDÆ [E. C. vol. iii. cols. 1031-1042]. The mussels form a group of molluscs which seem to have flourished from almost the earliest geological times, having representatives in strata of every period, from the Silurian to the present. In the present seas they are to be found on almost every shore. If organisms are related in any essential way with surrounding conditions of life, it may be surmised that through all the long æons of the past, as far back as the time above indicated, the conditions under which mussels may thrive have persisted with little if any modification. It is noticeable, not only that representatives of the family have formed a portion of the fauna of every period, but also that the same genus has been permanent in many districts, as, for instance, *Mytilus* in western Europe.

The *Mytilidæ* are closely allied to the *Aviculidæ*, the members of which agree with mussels in having the mantle open in front, and in having a short siphon, through which the water is drawn in, bearing with it the food on which the molluscs live, and the air required for breathing. The mussels, however, differ from the *Aviculidæ*, in having the mantle open in front only, and in having the posterior portion folded into a wide excurrent tube, forming a second siphon, through which the refuse of the system is expelled. The shell of the *Aviculidæ* is scaly, while that of the *Mytilidæ* is covered with an epidermis.

The definitions and limits of the principal groups present considerable variation amongst the authorities, but according to Mr. J. G. Jeffreys, the genera which are now living in British seas are *Mytilus*, *Modiolaria*, and *Crenella*. In addition may be added *Dreissena*, although some authors consider this genus to be the type of another but nearly allied family, the *Dreissenidæ*, as also *Modiola*, which Jeffreys merges in the genus *Mytilus*, as understood by him. The relationships of the first three genera mentioned in this paragraph will be partially gathered from the definitions given of them by Mr. Jeffreys, which we append.

Mytilus. Body subconical; mantle widely open in front; foot strap-shaped; shell oblong or oval; hinge often furnished with small tubercular teeth.

Modiolaria. Beck. Body suboval; mantle folded in front into a wide incurrent tube, and behind into a conical excurrent tube; foot strap-shaped; shell subrhomboidal, sculptured by two rows (one on each side) of striæ which radiate from the beaks, leaving the middle portion smooth; beaks incurved; hinge mostly toothless, but sometimes crenulated; hinge-plate finely notched.

Crenella. Brown. Body roundish oval; mantle open in front, and folded behind into a sessile excurrent tube; foot worm shaped, the point being disk-like, issuing out of a sheath; shell oval or rhomboidal, cancellated by longitudinal ribs and transverse plates; beaks straight; ligament small; hinge of each valve furnished with an upright tooth, which is crenulated, as well as the hinge-plate.

Of the genus as understood by Jeffreys, there are five species which frequent British shores. The most common is *M. edulis*. Its size is much influenced by the station which the individuals select; but whether large or small, the full dimensions are acquired in a single season. The specimens which take up their quarters in narrow chinks are frequently remarkably stunted, and yet their maturity is manifested by their being capable of developing eggs. Such stunted specimens are frequently more or less deformed, and constitute the variety *incurvata*. Other specimens attach themselves to chains and floating buoys, under which circumstances they are able to attain unusual dimensions; and these form the varieties *galloprovincialis* and *pellucida*. If modifications of external conditions, such as have been referred to above, are able to modify the size of this species, we may expect that similar changes may be produced on other species under like conditions, and this we believe is the case. The average size is 2·3 inches in length, and 1·2 inches in breadth. One of the largest specimens known is that described by Dr. Nordmann, from Edgecombe Isle, off the coast of North America, which is upwards of 9 inches in length, and 4¼ inches in breadth. *M. modiola* is a second species, which is frequently regarded as the type of a distinct genus; but Jeffreys follows Deshayes in his conclusion that there is no need to have two genera when the characters of the one merge into those of the other. This species is a more northern shell than *M. edulis*, and its British habitats are near the southern confines of its limits. The usual size is 5 inches in length, and 2½ inches in breadth; but in one variety the size is usually only 3 inches in length by 2 inches in width. Some specimens, however, far exceed the above dimensions, and may attain a length of 9¼ inches. *M. barbatus* is a small species, which chiefly frequents the Mediterranean, and its northern range just extends to the southern shores of the British islands. *M. adriaticus* is a still smaller species, and, like the last mentioned, is far more common in the south than in the north of Europe; the northern specimens are, on the average, larger than those from the south. The average size is 1·2 inches in length, and ·7 inches in width. *M. phaseolinus* is the smallest of the British species, the length of an average-sized specimen being ·65 inch, and the width ·375 inch. It is to be found on almost every tract of rocky ground below low-water mark in the seas surrounding the British islands, and ranges from the Mediterranean on the south, to the North Cape on the north. As is the case with other species, the southern specimens are smaller than the northern.

The genus *Modiolaria* has four British representatives, all of which are small as compared with the species of *Mytilus*. The sizes seem to be correlated with the latitude, for, roughly speaking, the species which have the most southern areas are smaller than those which extend farther north. The largest is *M. nigra*, its average size being 1·65 inch in length, and ·65 inch in breadth. It is an exclusively northern species, abounding on all the Scandinavian shores, as also on the coasts of Greenland, Newfoundland, and Massachusetts. Its most southern range, so far as known, is the Dogger Bank, off Yorkshire. The size is subject to much variation, and sometimes the length is 2¼ inches. *M. marmorata* follows next in order of size, the average length being ·75 inches, and the width ·45 inches. It is not known to be an inhabitant of American seas, and in the European area its range extends from Finland to the Ægean. *M. discors* has an average length of ·5 inch, and a width of ·35 inch; but in one variety the length is only ·175 inch, and the width ·1 inch. Its habitat is more especially amongst the roots of seaweeds. It has a wider range than the foregoing species, extending from Greenland to the Ægean Sea. It is subject to much variation, and some of the varieties have been regarded as distinct species; but we think Jeffreys is right in condemning the practice too prevalent amongst zoologists of establishing species upon insufficient material. Thus, he says, with reference to the varieties of the present species, that "the gradual passage from any one of these forms to another is very evident, if a sufficient number of examples of all ages and from many localities are submitted to the inspection of a tolerably practised observer; and the deplorable fashion of species-making might be in some measure restrained by adopting this method in all cases, instead of selecting a few particular specimens and discarding young shells and those which offer inconvenient proofs of transition." *M. costulatus* is the smallest British species, the usual length being ·4 inch, and the width ·2 inch. It lurks beneath stones and amid sea-weeds in rocky pools. It occurs on the southern shores of the British isles, but it flourishes better in more southern seas, extending as far as the Canary isles.

Of *Crenella* two British species are known, both of them minute. *C. rhombea* has a length of ·13 in., and a width of ·2 in. It has been discovered in a few localities on the south coasts of England, and in none of them is it plentiful, although, on the opposite side of the Channel it is far more abundant. *C. decussata* has a length of ·15 in. and a width of ·12 in. It is more or less abundant all round the northern shores of the British Isles, and extends farther north into the seas of Scandinavia, Iceland, and Greenland. The following account of its habits is from Mr. Jeffreys' work. "This exquisite gem of a mollusk is hardy, and active. Not being able to examine living specimens at the time they were taken, I picked out a few from a small heap of dredged sand, which had been lying on a pathway for two days, exposed to continual rain, and partly trodden under foot. After keeping them for eighteen hours in a small glass vessel of sea water, they revived, and were alive for many days, the water being occasionally renewed. While crawling about, they sometimes carried the shell erect, with the beak in front, but more frequently in a slanting position. They seemed fond of getting to the surface of the water, when the *Crenella* would spin with its foot a single pellucid thread, which it fixed to the side of the vessel, and it would hang (like a *Sphærium*) for hours thus suspended, the beaks of the shell being undermost. The shell being nearly transparent during the lifetime of the animal, the green liver is distinctly seen through it, occupying the umbonal region. The foot stalk or pedicle is semicylindrical, and becomes twisted if the animal is placed on the wrong side. The creeping disk or lobe is very flexible, and in some degree extensile. It is half as broad again as the stalk, and proportionally thicker. A dusky line runs down the middle of the stalk, apparently showing the muscle which connects the terminal lobe with the basal attachment of the foot to the body. While the animal is crawling a tremulous movement is seen to pervade the lobe. The stalk and sheath are faintly wrinkled across. The foot is protruded from the ventral opening in the mantle, and extends in a direction opposite to that of the beaks."

Dreissena is a fresh-water genus, as has already been indicated in the E. C., where reference is made to the distribution of *D. polymorpha*, whose recent extension into many of the rivers of Western Europe forms one of the most remarkable episodes in the history of molluscan life. In this extension the genus is only regaining the ground which it occupied in former tertiary times. One species is especially common in the tertiary fresh water basin around Vienna, some of the beds of which are designated the 'Congerien-Schichten' from the abundance of the *Dreissena* shells in them. *Congeria*, we may notice, is one of the synonyms of this genus. The true home of *D. polymorpha* appears to be the Caspian Sea and its affluents (from whence the earliest specimens which were scientifically described were obtained), and the other lakes of Western Asia. Less than half a century ago this species was unknown throughout the North and West of Europe, occurring in none of the local lists drawn up before about 1820. Soon after this it was discovered in several places at once, and since then its further extension has been under close observation. England was one of the first countries to which it made its way, the date of Sowerby's discovery being 1824. In 1825 it was received from some of the streams which flow into the Baltic; in 1826 it found its way into the Rhine basin; in 1828 into the Elbe basin; in 1833 into the basin of the Meuse; about 1834 it was first observed in Scotland; in 1838 it was first seen in France; in 1856 it was first detected in the Loire; and since then it has been gradually invading other streams, and working its way more into the central and higher portions of the Continent. The facts that have been accumulated indicate that the spread of the species has been effected in great measure by the indirect agency of man. The principal means has been the transportal of timber, and this is quite in harmony with the circumstance that the earliest *foci* of extension were the chief ports of Western Europe; and that in many instances the first localities noticed were canals connected with the rivers, and not the rivers themselves.

(Jeffreys, *British Conchology*, vol. ii.; Fischer, P., *Journ. de Conch.*, xii., p. 309; Woodward, *Manual of the Mollusca*, 2nd edition; Chenu, *Manuel de Conchyliologie; Zoological Record*, vols. i., ii., iii. and iv.)

N

NANNOPERCA. A genus of fishes belonging to the family *Percidæ*. Dr. Günther defines it as having the body compressed, oblong, and as being covered with scales of moderate size. There is no recumbent spine before the dorsal fin. The anal spines are three in number. Narrow bands of villiform teeth occur on the vomer and on the palatine bones. None of the bones of the head are serrated. Branchiostegals, six; pseudobranchiæ present. Lateral line, none. Only one species is known, *N. australis*, from the Murray river.

(Günther, *Proc. Zool. Soc. for* 1861, p. 116.)

NATICA, a genus of *Mollusca*, which is usually associated with the holostomatous species, or those which have the apertures of the shell entire, and most of which are phytophagous in their habits. *Natica*, however, is eminently carnivorous, having a largely developed foot, which is frequently expanded to twice the breadth of the shell. By means of this foot the species creep along tolerably actively, buried in the sand or sandy mud, tunnelling along so close beneath the surface that when they settle down to rest, their place is indicated by a small heap or mound. The foot is capable of great alterations in size; the changes appear to be effected by the absorption of water into the numerous canals which traverse it, from which the fluid is again expelled. Hydrostatic power thus greatly facilitates its passage through the sand. The object of this burrowing is to search for the sand-loving bivalves, more especially the species of *Mactra* and *Tellina*, which when found they hold fast by means of their powerful and flexible foot, and leisurely drill a hole through the shell, so as to enable them to obtain the soft muscular tissue within. As they are mostly excluded from the light, and must necessarily search for their prey by other sense than sight, it is in harmony with their habits that their eyes should be absent or small, and when present covered over by the outer integuments. It is also, probably in correlation with such habits, that the head is provided with a large flap or hood, which extends backwards so as to overlap the fore part of the shell, leaving only the extremities of the tentacles exposed. The sides of the foot, and the upper portion just at the back of the shell, are turned up so as to entirely close in the aperture, an arrangement which seems manifestly adapted to prevent the inconvenience that might arise from the sand being forced into the shell. The shell itself is covered with an epidermis, which is usually rubbed off, a small portion only generally remaining within the umbilicus. In Lovell Reeves' monograph of the genus, 143 species are described and figured. In the present article we shall confine ourselves to the British species. Its first appearance on the British area dates from a far distant era, since one or more species frequented the seas of the middle and upper Devonian periods, since when it seems never to have entirely left the district, retreating only so far as the alterations in the boundaries of seas compelled it. At present there are believed to be six species, viz.: *N. Islandica*, Gmelin; *N. Grœnlandica*, Beck.; *N. sordida*, Philippi; *N. catena*, Da Costa; *N. Alderi*, Forbes; and *N. Montacuti*, Forbes; while *N. clausa* and *N. Smithii* were British at a very late geological period, but have since retreated northerly.

The commonest British species is *N. Alderi*. It presents more variation than any of the others, but the type form has more colour in the shell, and of a darker tint than any, although one variety has a milk-white shell. The eyes are distinctly visible; the size is below the average; the shell is very thick, solid, and glossy, and the aperture of the shell is unusually large; all which points render it a somewhat extreme representative of the genus. It is found on all the sandy bottoms along the British shores, whatever be the depth. Its greatest range north is to the Loffoden Isles, or about 68° N. lat.; and to the south it is found all along the west coasts of Europe; on both sides of the Mediterranean, and in the Adriatic, extending at least as far as 35° N. lat. The range is about 33 degrees of latitude. Its range in depth is from 3 to 80 fathoms. It has been found in the post-pliocene deposits of this country and of Norway. The geological record is incomplete, but it seems to have expanded its range within recent times.

N. catena is another common species, but is apparently somewhat less abundant than the foregoing. Like it it has purplish brown tints mingled with the lighter yellow back-ground of its body; like it it has long, slender, and pointed tentacles; and like it it has a largely developed foot. The eyes are, however, only just visible, the shell is more globose, twice as large in length and breadth, and not so thick and solid. It frequents sandy bays, and seldom ranges beyond a depth of 10 fathoms; the specimens which are obtained in deeper water do not contain the animal, and have been carried there by hermit crabs. Its latitudinal range is similar to that of *N. Alderi*, being from Bohuslan to Corsica. It is abundant in the post-pliocene, as well as the newer and older pliocene deposits of Great Britain.

N. sordida, perhaps, comes next in order of frequency. The animal is lighter than the preceding two, having a slight patch of reddish brown at the extremity of the snout; the shell is buff coloured, and very nearly of the same size as that of *N. catena*, but not quite so globose. The eyes are not perceptible, the foot is very large, and the tentacles are tapering in outline. It frequents muddy sand at depths varying from 7 to 90 fathoms. It is not known much to the north of the Shetland islands, while to the south it has been recorded from various parts of the Scotch, Irish, and English coasts, and as far south as Algiers. Its latitudinal range is not much over 25°, and therefore less than that of the preceding species. As a fossil it ranges as far back as the older pliocene period, and as far south as Sicily; and hence it is possible that it has been gradually advancing northwards since the pliocene period.

N. Montacuti has a lightly tinted body, the only portions which are purplish brown being the edges of the auricular expansions of the foot; the tentacles are moderately long and pointed; the shell is globular, thick, solid, and with less glossiness than those of the species already noticed. The eyes are not visible, and the foot, when fully extended, has an area about twice that of the shell. Its habitat is on sandy or gravelly bottoms, mixed with mud, in depths varying from 15 to 90 fathoms. It is generally distributed on the shores of the British isles, but is not known to the south; on the north it is reported from Iceland and Sweden, probably as far as 70°. This would give a latitudinal range of 20 degrees. Very little is known of it in the fossil state beyond that it is found in the post-pliocene deposits of Scotland and Norway, and that a specimen is recorded from Palermo, which is believed to be fossil.

N. Grœnlandica is of a much lighter tint than any of the foregoing; the tentacles are much shorter, the eyes are imperceptible, and the foot is smaller. The shell is globose, and somewhat larger than that of *N. Alderi*. It prefers muddy sand in deep water, and has not been traced farther south than Yorkshire and North Ireland, or about 54° N. lat. Farther north it is living on all the Arctic shores of Europe, Asia, and America, from the shore to 150 fathoms. As a fossil it is known to occur in the pliocene and post-pliocene beds of the British isles, and to have ranged, during the latter period, into Norway on the east and to Canada on the west. Its area of distribution is essentially northern, and particularly extensive in the longitudinal direction.

N. Islandica is light in the colour both of the animal and shell, the tentacles are small, the eye imperceptible, and the foot is, comparatively with the common species, small. The form of the shell is oval, the length being at least a third greater than the breadth, and in substance it is thin, and semi-transparent. It is rare in the coralline zone from 7 to 79 fathoms, and is distributed about Ireland, the north of England, and Scotland. It probably has nearly the same southern limits as *N. Grœnlandica*, and like that species ranges into all the northern seas. It is frequent in the post-pliocene strata of the British islands, Norway, and America, and in the older pliocenes of Norfolk.

(Jeffreys, J. G., *British Conchology*, vol. iv. pp. 211-230.)

NEALOTUS. A genus of fishes established by J. Y. Johnson in 1865, and referred by him to the family *Trichiuridæ*. He defines it by the following characters:—Body elongated, compressed, incompletely clothed with delicate scales. Cleft of the mouth deep. Small teeth on the jaws and on the palatine bones; none on the vomer. First dorsal fin continuous, extending to the second; finlets behind the second dorsal and anal fins. Each ventral fin represented by a single small spine. A dagger-shaped spine behind the vent. No keel on the tail. Caudal fin well developed. Seven branchiostegal rays. Only one species is known, *N. tripes*, and that, it may be remarked, is based on a single specimen from the Madeiran seas.

(Johnson, *Proc. Zool. Soc. for* 1865, p. 434.)

NEMACANTHUS [E. C. vol. iii. col. 1079]. This genus of fishes is also found in the lower carboniferous strata of Ireland, where it is represented by *N. priscus*.

NEMACHEILUS, a genus of fishes of the loach family, of which several species inhabit the fresh waters of the Neilgherry hills of India.

NEOMÆNIS. A genus of fishes belonging to the order *Acanthopteri*. It was founded by Girard upon a species living in North America, and which Gill refers to the family *Pristipomatidæ*. The last-named writer gives the history of the nomenclature of this form, as also of a few others which resemble it in certain external points, and shows how ichthyologists of high repute have assigned species to some genus in one family which should really find a place in a genus of a closely allied family; and from this he argues that the distinctions between the *Percidæ* and *Pristipomatidæ* must be slight. Indeed he carries his views of amalgamation still further, and believes it probable that the typical *Percidæ*, *Pristipomatidæ*, *Sparidæ*, and *Pimelopteridæ*, will be found to belong to one true family. They cannot, he remarks, be distinguished, except by their dentition; and characters having this basis he considers are not of family value. The *Lutjanus* of Bloch is synonymous with the present genus.

(Gill, *Proc. Philad. Acad. for* 1861, p. 93.)

NEROPHIS. A genus of fishes. One species is remarkable for being an inhabitant of the Baltic Sea, where it is associated with a number of other species which like itself belong to genera habitually frequenting the ocean. The Baltic is far less salt than the neighbouring German Ocean, and yet this species and a few more which appear to have originally come from the German Ocean are able to live in the Baltic Sea alongside with other species which belong to true freshwater faunas. Associated with these we also find a group of species which evidently originally belonged to the fauna of the Glacial or Arctic Seas. Such a collocation of species indicates great changes in the distribution and connections of the seas and lands of the Scandinavian region since these species were called into being as such.

NERVOUS SYSTEM [E. C., vol. iv., cols. 5-30]. Although the recent literature on this subject is very voluminous, and our knowledge respecting it is gradually progressing, still there are many doubts and difficulties, as well as many misconceptions, which require to be removed, before a clear idea can be obtained as to the structure and mode of action of this complicated arrangement of fibres and cells. The essential data for a true and comprehensive account have yet to be discovered; amongst them the most important are those relating to the physical structure, the chemical composition, the forces which are associated with it, and the laws by which those forces are regulated. No doubt, as the former article sufficiently shows, many facts have been collected bearing upon each, but a large proportion of them are open to doubt or inapplicable. Thus, as regards the structure, it is necessary to convince oneself that the appearances described are the true exponents of the healthy nerve in the living animal; so that it is important to remember that most structural details are based upon the examination of animals which are dead. The mere fact of their being dead implies that there is some material alteration, and as the nerves are so intimately connected with life and intellectuality, there is a probability that they may have undergone some alteration not only of property but of structure, a probability heightened by the consideration that all organic tissues change very rapidly when withdrawn from their normal connections and surroundings. The elements of nerve substance are cells and fibres. In the opinion of some anatomists there is no intimate union between them, but according to most authorities the fibres originate in cells, and Dr. Beale has brought forward strong evidence in favour of the view that all fibres originate in cells, and that, consequently, there are no free fibres and no free cells. This remark doubtless applies to the mature fibres and cells, for there is much reason to believe there are some independent cells. If fibres originate in and grow out of cells, the changes which take place during the development would be an important item of knowledge. However this may be, the two differ, the fibres being white and having homogeneous contents, while the cells are grey and have granular and nucleated contents; and this difference of structure is associated with difference of function. In the living state the fibre would seem to be a cylindrical membranous tube (neurilemma) filled with a fluid or pulpy substance (which may be termed neurine); but according to Remak and others there is in this neurine an elastic solid flat band (the axis fibre), but this last has not been detected in living nerve. The cells are mostly agglomerated in masses, forming the principal nervous centres, while the fibres constitute connections between the centres and between the various parts of the body. The fibres are, as has already been stated, grouped together into a common sheath, forming what is known as a nerve; the nerves may be bifurcate, split up into branches, and intercommunicate, but, as is believed, the primitive fibre is single from end to end. The mode of termination of the fibre is uncertain; formerly the prevalent opinion was that most of the fibres ended at the peripheral portions of the body, but latterly the tendency has been to the conviction that many, if not all, the fibres double back and return to a nerve centre, while Dr. Beale maintains that each fibre issues from a cell, and however long its course may be, returns to the same cell. As regards the composition, the great bulk of our information consists of a few analyses, but as yet we are in entire ignorance of the true chemical nature of many of the compounds, more especially those which form the contents of the cells and tubes; and still less is known as to what relation there is between composition and properties. As an indication of the unsatisfactory state of knowledge, we quote Mr. Foster's account, as given in Watts' Dictionary of Chemistry, vol. iv., p. 32. "Fremy represents 100 parts of cerebral substance as consisting of 80 water, 5 fat, 7 albumen, and 8 extractives and salts. Von Bibra gives 75·6 per cent. water, and from 12 to 16 per cent. fat. The 'white' matter contains less water than the 'grey,' the mean of the former being 73 per cent., of the latter 85 per cent. The white is richest in fat, producing 14·8 per cent., while the 'grey' has only 4·7 per cent (Lassaigne). According to Von Bibra, the spinal cord contains less water and more fat than the brain, viz. 66 per cent. of water and 25 per cent. of fat, while the nerves again have less water and more fat than the spinal cord, though the quantities seem to vary excessively. Schlossberger (Müller's Archiv. 1858, p. 309), gives the brain of a fœtus as containing from 87·9 to 92·6 per cent. of water, and from 1·6 to 3·7 per cent. of fat; results very closely agreeing with those of Von Bibra. In 100 parts of fresh brain, Breed found 6·627 ash, in 100 parts of which were :—

Phosphate of potassium	55·24
„ sodium	22·93
„ iron	1·23
„ calcium	1·62
„ magnesium	3·40
Chloride of sodium	4·74
Sulphate of potassium	1·64
Phosphoric acid (free)	9·15
Silicic acid	·42

No department of physiological chemistry has been so little studied, or studied with so little profit as that of the nervous system. Exact knowledge concerning the protein compounds in it is wholly wanting. The substance forming the axis cylinder seems to belong to the same series as fibrin and syntonin (myosin); it differs from the former by its insolubility in a solution of nitre, from the latter by its insolubility in dilute acids. The protein constituent of the medullary substance and of the cell contents seems to be some form of soluble albumen. It has been thought to be casein. Our acquaintance with the peculiar fatty abundance is also very unsatisfactory. Besides cholesterin which occurs to the extent of 20 per cent. of total fat (Von Bibra), olein, stearin and palmitine, there have been obtained various bodies whose nature is much disputed. W. Müller found in human brain a small quantity of creatine ·05 grm. in four pounds; in ox brain he found no creatine, but a body resembling leucine together with uric acid and xanthine or hypoxanthine. He also found in the same brain a very considerable quantity of inosite, 20 grms. in 50 pounds. Lorenz (Henle-Meissner, 1859, p. 290), found no creatine, leucine, inosite or lactic acid; he obtained, however, both xanthine and hypoxanthine. Herz (*ibid.*, 1860, p. 311) corroborates Müller. M. Schultze found urea and creatinine in the electric organs of the torpedo. Formic and acetic acid are said to be obtained by the distillation of the watery extract of brain. The presence of the above crystalline bodies indicate a metamorphosis, very similar to that which probably takes place in muscles; but we know nothing of the various steps. The large amount of phosphorus in nervous tissue (1·388—1·79 per cent. of dry brain substance, according to Borsarelli) has prompted many to attribute much to that particular element. Mental effort is said to increase the phosphates of the urine; but whether directly or indirectly is uncertain. Neukomm (Arch. Anat. Phys. 1860, p. 1) found in human brain, in various diseases, leucine, creatine and inosite, the latter at times in very notable quantities. Tyrosine was invariably absent. Grohe (Med. Centr. 1864, p. 870) found glycogen (without sugar) in the brain of a diabetic."

Our knowledge respecting the properties of nerves, and the mode in which they bring about various functions is also involved in obscurity. The received doctrine is that a sensation produced by an external object is conveyed to the brain in some way by nervous filaments specially adapted for the purpose, and that a force analogous to electricity is generated in the nervous centres of grey matter, which is transmitted to the organs whose functions are to be stimulated. The idea entertained by some is that the force is not merely analogous to, but is even a modified kind of electricity, following the same laws as it, but as the idea is at present merely a hypothesis, caution should be exercised not to raise it to the rank of a theory. The structure of a nervous filament is, as regards general form, very similar to that of an electric wire; there being in each a solid central core, an enveloping medium, and an external protective membrane; but as regards the nerve it has to be proved that the solid core is a conductor of electricity, and the medium, an insulator thereof. It has also to be proved that force is generated only by the grey matter and transmitted by the white. Indeed, there are a few facts which indicate that the force is in part resident in the nervous filaments, and that the ganglions and other centres mainly act as liberators of that force. Lewes insists that, at any rate, the nerves have a force of their own, which he distinguishes as neurility. Thus he notices that if a frog's leg be detached from the body, and the sciatic nerve be separated from its centre, the application of the galvanic battery will cause the muscles to contract. This may naturally be attributed to the electrical current from the battery having replaced the nervous current from the centre; and since the two bring about the same result, the two forces are similar or perhaps identical. If, however, before any battery has been applied, a simple prick with a needle or a bit of wood, or almost any substance with a sharp point, be given to the nerve, the muscles will contract; and this operation may be repeated at intervals for many days and weeks in succession with a similar result. In this case it can hardly be maintained that any force is derived from the sharp point; rather it would seem that a mechanical action is sufficient to stimulate the nerve to liberate the required amount of force. A practical illustration of this is afforded by the strong sensation experienced when the ulnar nerve is suddenly struck, and the numbness which follows its prolonged pressure; the nervous force inducing sensibility, a property believed to be inherent in the ganglionic centre, as contractility is in the muscles. The aptness of the illustration is entirely lost if the idea is entertained that some nerves are motive and others sensitive, mainly on account of difference of structure. As yet there is no evidence of any such difference, nor is there any proof that both kinds of nerves are identical, as is assumed by Lewes.

The latter assumption, however, will harmonize with the view that all the nerves have the same properties, but that their functions differ in virtue of differences in their connections, and the conditions which act upon them. Most of the filaments which issue from the posterior root of a nerve originating in the spinal chord, give rise to sensation when stimulated, while most of those from the anterior root elicit muscular contractions. Hence, the one set are called afferent or motor, and the other efferent or sensory; but it is premature to assume that a nerve is only concerned in exciting motion when it is afferent, and *vice versâ*. It is also premature to assert that a nerve which is ordinarily engaged in exciting sensation is incapable under any conditions of inducing muscular contraction. According to Lewes, there is no radical difference between the two sets of nerves, but the motor nerves are so because they terminate or abut peripherally upon muscles, and not upon an organ of sense. If the sense organ be wanting, no sensation is experienced unless we can functionally supply the place of such organ. Hence it is that a mere tickle on the skin is transferred to the nervous centre as a sensation, while the same circumstance will have no effect if applied to the sensory nerve, or to the centre itself.

NESIARCHUS. A genus of fishes belonging to the family *Trichiuridæ*, and established by J. Y. Johnson in 1862. His definition is embodied in the following words:—Body elongate, covered with small scales. Cleft of mouth deep. Several strong teeth in the jaws; none on the palatine bones or the vomer. First dorsal not extending to the second. No finlets behind either the dorsal or anal fin. A dagger-shaped spine behind the vent. No keel on the tail. One lateral line. Seven branchiostegal rays. An air-bladder. Pyloric cæca in moderate number. This genus is based on a single specimen from the Madeiran seas, for which the specific appellation, *N. nasutus*, has been retained.

(Johnson, *Proc. Zool. Soc. for* 1862, p. 173.)

NIPHON. [PERCIDÆ, E. C. vol. iv. col. 263.]

NITROGEN. Although the circumstance that animals and plants are incapable of living in an atmosphere of this gas has obtained for it the name of azote, yet it is one of the few elements which are essentially connected with life as developed upon this earth. It enters largely into the composition of ammonia, and nitrous acid, one or other of which is believed to be amongst the most important ingredients of plant food. It forms part of the vegetable alkaloids, which are remarkable both for their complicated constitution, and for their physiological effects on the animal economy. It is also a constituent of the various protein compounds, which enter so largely into, and play so important a part in the structure of animals. Indeed, nearly all the native compounds of nitrogen are so intimately connected with life that whenever ammonia is evolved from a substance on the application of heat it may be confidently inferred that organisms have been in some way or other associated with that substance.

Free nitrogen has been found in several localities; the great bulk of it exists in the atmosphere mechanically mingled with oxygen, while smaller quantities occur in certain cavities of fishes and other animals, as also in plants, in springs, and in the exhalations from volcanic craters, and from the fissures formed by earthquakes. In the atmosphere the relative volumes of the nitrogen and oxygen is as 79 to 21, but in the other sources just mentioned the proportion of oxygen which accompanies it is nearly always far less than this. In most cases where the nitrogen thus predominates over the oxygen there is reason to believe that the source of the mixture has been the atmosphere, and that a portion of the latter gas has been spent in oxidation. The following illustrations will afford some idea of the evidence on this point.

In *Physalia*, a remarkable hydrozoan genus, frequently found floating on the surface of the warmer European seas, there is a large cavity filled with air, which communicates with the atmosphere that surrounds it. The walls of the cavity consist of a highly elastic cartilaginous-like substance; by means of muscles this bag is caused to collapse, and the air is partially expelled; the natural elasticity of the walls restores the cavity to its original shape, and in so doing draws in the surrounding atmosphere. On examining the gas contained in the cavity, Quatrefages found that from 2 to 3 per cent. of the oxygen had disappeared. Something similar occurs in the air bladders of fresh-water fishes; the contents of which consist of nitrogen, with a small per-centage of oxygen, and a trace of carbonic acid. Thus Humboldt found 96 per cent. of nitrogen, and 4 of oxygen in the air-bladder of the electric gymnotus. In deep sea fishes, on the other hand, oxygen generally predominates.

The majority of warm springs, situated at a distance from active volcanic areas, constantly yield bubbles of gas. There is a remarkable general uniformity in the nature of this gaseous exhalation, and as an example we would refer to the largest springs at Bath. According to Dr. Daubeny the composition of the exhalation is 4·5 per cent. of carbonic acid, 3·8 of oxygen, and 91·7 of nitrogen. On the assumption of the original derivation of these gases from the air, the nature of the change is indicated by comparing the volume and proportion of gas contained in 34,900 cubic inches of the Bath waters, and of an ordinary pump water from a calcareous district.

	Bath-water. Cubic inches.	Pump-water. Cubic inches.
Carbonic acid; dissolved . .	1012	698
„ free	12	
Nitrogen; dissolved . . .	140	314
„ free	245	
Oxygen; dissolved	70	167
free	10	
	1489	1179

As regards proportion, then, this indicates that while the carbonic acid and nitrogen were increased, the oxygen was diminished. The increase in carbonic acid would naturally arise from increased pressure; while the relative increase of nitrogen might be attributed to a portion of the oxygen having combined with substances met with during the passage. Considering that this great predominance of nitrogen over oxygen is met with in all warm springs unconnected with volcanic areas, it has been suggested that the warmth of the spring is in great measure due to the heat evolved by the formation of the oxidized products.

There are many instances known in which nitrogen is emitted from volcanoes, accompanied by less than its usual complement of oxygen, such as Vesuvius, Lipari Islands, Etna, and others. In those cases also Dr. Daubeny thinks the heat may be due more or less to the oxidation effected by the unrepresented oxygen deep beneath the earth's surface.

NOTORNIS. Under DINORNIS, E. C., is given Dr. Mantell's account of the Australian species, *N. Mantelli*, which was first discovered by his son. The earlier specimens found consisted of semi-fossil bones, and subsequently a live individual was captured, which was until recently the only reliable evidence known that this bird was not extinct. The species, however, has not wholly disappeared yet, and it is to be hoped some specimens will be secured for our museums while there is yet time. In 1865 the Otago gold-fields were opened up, and the country was traversed in many directions by prospectors and diggers. Being driven by stress of hunger to procure what food they could by personal search, some of them are said to have subsisted for days on what they called the 'great ground parrot,' but which there is no doubt is really *N. Mantelli*. As yet, living specimens have been obtained only in the south-west corner of Middle Island, and it is not unlikely they may be restricted thereto. The principal reasons why the species has maintained its ground here, so long after having been exterminated from most other districts, are that wild dogs and cats had not established themselves there before 1865, and that bush fires have been rare. Now that the white man has introduced himself, he will doubtless be followed by those destructive influences which have played such havoc on the native fauna and flora in every place which he has colonized in New Zealand. And as the Moho is less capable of withstanding such influences than the small and rapid running Weka, and the climbing *Strigops*, owing to its large size, comparatively slow speed, and incapacity for flying or climbing, it may be expected that before long it will be annihilated from this area, which seems to be its last stronghold. Could not efforts be made for the preservation of this species? Gould infers that it is shy in its habits; that it trusts to the power of its feet, not of its wings, for escape from its enemies, and that it frequents low lying moist sites. This latter habit he thinks is indicated by its thick plumage and long back feathers. The same authority thus describes the external appearance of the bird; but as it is apparently based upon a single individual, it will probably require slight modifications when fuller materials are obtained. "Head, neck, breast, and upper parts of the abdomen and flanks purplish blue; back, rump, upper tail coverts, lesser wing coverts, and tertiaries, dark olive green, tipped with verditer green; at the nape of the neck a band of rich blue separates the purplish blue of the neck from the green of the body; wings rich deep blue, the greater coverts tipped with verditer green, forming crescentic bands when the wing is expanded; tail dark green; lower part of the abdomen, vent, and thighs, dull bluish black; under tail coverts white; bill and feet bright red. Total length of the body, 26 inches; bill from the gape to the tip, 2⅛; from the tip to the posterior edge of the plate, on the forehead, 3; wing, 8½; tail, 3½; tarsi, 3½; middle toe, 3; nail, ⅞; hind toe, ⅞; nail, ¾."

The foregoing species is, however, not the only one which has flourished in New Zealand. A still larger one has left its bones in association with the gigantic *Dinornis*, with which genus indeed it has long been confounded, being best known by the name of *Dinornis casuarinus*. That it is really a gigantic rail, and not a *Dinornis*, is fully pointed out by Mr. Parker in the 'Philosophical Transactions' for 1866, p. 163 *et seq.* He institutes a comparison between the skull of this species and that of *Dinornis robustus*, with a view to showing their distinctness, and proving that the former is really a *Notornis*. He remarks that the process on the basitemporal bones is larger in this *Notornis* than in any other bird, the next to it in this respect being *Sarcorhamphus papa* and *Chauna chavaria*. All these retain the basitemporal pterygoid processes of the lizard. In the lizards there is the merest trace of a basisphenoidal rostrum, and in *Notornis casuarinus* it is exceedingly small, far smaller than in other rails. In the ostriches it is very large. The os quadratum has a double head of a concavo-convex form, a broad metapterygoid process, and a dimple-shaped pterygoid process. In this last feature it agrees with the lizard, but differs from *Dinornis*. He also makes the significant remark that in all essential details the skull of the extinct gigantic *Notornis casuarinus* corresponds with that of a chick of a living *Gallinula*. The sternum of *N. Mantelli* indicates the cursorial habits of the bird; and is not more developed than in some lizards. The keel is inconspicuous, and the blade forms a narrow marginal plate to the keel.

We have indications of a third species, which formerly inhabited the Madagascar group of islands. It is mentioned by Du Bois, who travelled in those islands during the years 1669-1672, as "blue birds, as large as the solitaire, with blue plumage, red feet and beak like those of a fowl; they do not fly, but run well, so that a dog can scarcely catch them; they are capital eating." This passage might be applied to *Notornis Mantelli*. Strickland assigned the Madagascar bird to *Porphyrio*, but expresses doubts as to the correctness of the assignation owing to its large size, and its galline feet. These objections have lost their weight since *Notornis Mantelli* has been known, for this bird is as large as a goose; and many *Rallidæ* have the three digits spread out in the true galline fashion, as in *Notornis, Tribonyx*, and *Ocydromus*. Selys Longchamps called it *Aptornis cærulescens*, and placed it amongst the *Struthionidæ*, guided as it would seem mainly by the fact that it does not fly; but the New Zealand *Notornis* is, as already mentioned, incapable of flight, and *Ocydromus* is very ill adapted for that mode of locomotion. Schlegel says it is unquestionably allied to *Porphyrio*, and considers it ought to be relegated to the genus *Notornis*, which he regards as the galline modification of rails, on account of its great size, thick tibia, short digits, and heavy form. This view he thinks is corroborated by the fact that the Mascarene islands are within the limits of the generic area of *Porphyrio*, which extends from Central Europe through Africa, Madagascar, India, Australia, and New Zealand. *Tribonyx*, we may mention, is an Australian genus. As regards the size, Schlegel thinks this is not a valid objection, since he observes that it is usual for the southern representatives of an extensively distributed ralline genus to be remarkable for size. He alludes to *Notornis* as compared with *Porphyrio*; to the *Tribonyx* and *Gallinula gigantea* of the south as compared with the *Gallinula* of Europe; to the *Fulica gigas* of Peru and the common coot; and to the strange *Chauna* of South America. The weak wings, he observes, is a common feature in this area, and is apparently associated with external conditions, more especially the non-prevalence of predaceous mammals.

(Schlegel, *Ann. des Sciences Naturelles*, 5ᵉ Serie, vol. vi. p. 38 *et seq.*; Parker, *Philosophical Transactions*, 1866, p. 163 *et seq.*; Gould, *Handbook to the Birds of Australia*, vol. ii.; Mackay, *Ibis*, for 1867, p. 144.)

NOTOTHENOIDÆ. The name of a family of fishes, the species of which have hitherto been referred by most authors to the families *Sciænidæ* and *Gobiidæ*. Its definition is couched in the following terms. Body oblong or elongated, generally highest at or near the nape, and thence slowly and regularly decreasing to the caudal fin, where it is most compressed; anteriorly subcylindrical. Preanal region generally shorter than the head, rarely longer. Skin covered with regularly imbricated scales of moderate size. Lateral line running high on the sides and near the dorsal fin, rarely uninterrupted; generally terminating near the end of the dorsal, and reappearing along the middle on the sides of the tail, and thence continued to the caudal fin. Head moderate, scarcely or not at all compressed, with the snout moderate and little decurved. Eyes moderate, lateral, but partly visible from above. Infra-orbital bones very small, and not articulated with the preoperculum. Opercular bones all present, normally developed and unarmed. Nostrils double, between each eye and the snout; the anterior very small. Mouth terminal, with the cleft lateral, and extending near the vertical of the eye. Upper jaw formed chiefly by the premaxillary bones, which are scarcely protractile, the ascending or posterior processes being very short. Supra-maxillary bones expanded towards the ends as usual, mostly retractile under the pre-orbital. Lips tumid. Teeth acute, present on the jaws. Palatines smooth. Branchial apertures capacious. Branchiostegal membrane below deeply emarginated behind, and provided on each side with six rays. Pseudobranchiæ developed. Dorsal fin double, the spinous portion commences near the nape, is short, and distinct from the soft part; the latter is elongated. Anal fin little shorter than the soft dorsal, and unarmed, with its rays divided like the dorsal, and the membrane notched behind each. Caudal fin moderately developed, and not forked. Pectoral fins well developed, with broad bases normally inserted on the scapular arch; its lower rays are branched. Ventral fins jugular, each provided with a spine and five branched rays, the third or fourth of which is generally longest; rarely the second. The cranium is nearly, or quite, smooth above, and the crests and ridges are rudimentary or obsolete. The vertebræ are in greatly increased number; in one species (*Notothenia purpureiceps*) there are forty-six, fifteen of which are abdominal. The stomach is moderate and cœcal. Pyloric appendages are present in small number, or from 3 to 5.

This family is sub-divided into two sub-families, including between them three genera, as indicated in the subjoined synopsis.

Nototheniinæ.—Lateral line interrupted. Body regularly tapering.
  Notothenia.—Abdominal region shorter than head. Dorsal spines slender.
  Macronotothen.—Abdominal region longer than head. Dorsal spine short and stout.
Eleginiinæ.—Lateral line continuous. Body sub-fusiform.
  Eleginus.—Abdominal region shorter than head. First dorsal triangular.

This group is thought to hold a position in the fauna of the southern seas analogous to that of the cod fishes in the northern. The *Nototheniinæ* chiefly frequent the seas near the Falkland Islands and Kerguelen's Land. The *Eleginiinæ* extend farther towards the equator. In the under-cited paper a synopsis of all the species is given, the number recognised in each genus being in the case of *Notothenia*, 11; *Macronotothen*, 1; and *Eleginus*, 3.

(Gill, *Proc. Philadelphia Academy for* 1861, p. 512-522.)

NOTURUS, a genus of *Pimelodinæ*, of which four species inhabit the United States. The body is rather stout; the head depressed, oval, and covered with a thick skin. There is a median longitudinal and transverse nuchal groove. Superoccipital bone posteriorly free. Mouth wide. Branchiostegal membrane with seven to nine rays on each side. Anterior dorsal fin, with a short, smooth, and acuminated spine. Adipose fin cariniform, elongated, and compressed, generally united with the procurrent rays of the obliquely truncated caudal fin. Caudal peduncle with the extremity obliquely subrotundate, truncated downwards and forwards. Ventral fin with nine rays.

(Gill, *Proc. Bost. Soc. Nat. Hist.* vol. viii. p. 45.)

NUTRITION [E. C. vol. iv. cols. 53—54; FOOD, E. C. vol. ii. cols. 851—867]. By nutrition is meant the processes by which certain kinds of matter are incorporated with the system so as to elicit the production of that force, whether potential or actual, which is manifested in every living organism. The subject may be regarded either from a broad or a narrow point of view. In the former case, the general character of the matter used, and the general results only are made matter of consideration; while in the latter case attention is more particularly paid to the distribution of the matter and forces to the different parts of the body, whereby the relative sizes and forms of those parts are regulated. Nutrition consists of three stages: first, the supply of material to the tissues; next, the metamorphosis of tissue, accompanied by the liberation of force; and lastly, the expulsion of the products when of no further use. In general aspect, then, an organism resembles a machine, such as a steam engine, inasmuch as in both there is a supply of material, a portion of which is subjected to a synthetical change productive of force; and the rest, which is not adapted to undergo synthesis, and to be a force liberator, is rejected. But there are important differences between them, such as that the organism uses a portion of its material for the purpose of keeping the working parts in constant reparation, as well as for regulating the distribution, retention, and manifestation of the force; and that the result consists not only of heat and mechanical power, but also of many other kinds of force. The steam engine is simplicity itself as compared with a healthy man.

Since the principle of the conservation and correlation of force has been received, physiologists have been labouring to elucidate the complicated phenomena of life in accordance with that principle. Thus, instead of assuming that the actions of a living organism are brought about by the application of a vital force which produced a waste of tissue, it is now more usual to believe that the force is resident in the material, and is liberated therefrom by the changes which it is made to undergo. The great bulk of that force is energy derived from the sun and stored up in plants. No material is destroyed and no force is annihilated: the utmost that is done is a shifting in the arrangement of chemical elements and in the distribution of energy. If we could trace all the accessions of matter and of force, as well as of their expulsion from the body, which occur during the lifetime of each individual, we should be able to form a clear idea of what are the laws of nutrition. At present we are far from having arrived at anything approaching to complete knowledge; but we know enough to be able to say that the energy in the animal is mainly in consequence of chemical union of a special kind, viz., oxidation. The scope of the study is so vast, and so difficult of pursuit, that most physiologists confine themselves to its more practical aspects, such as are conveyed in the following words:—"The animal body consists of certain kinds of material with force so associated with them, that the decomposition, or the metamorphosis, in other words, the oxidation, of each material sets free an approximate force and gives rise to a corresponding waste. Thus amongst other things the body contains certain quantities of nervous, muscular, and adipose tissues, whose decomposition may be said to give rise to muscular, nervous, and calorific action, the development of each action being accompanied by its particular waste. The object of the study of nutrition is to ascertain qualitatively and quantitatively the things which are best suited when taken into the body to ensure the acquirement of one, several, or all of the various corporeal constituents, and thence to guarantee the exhibition of the force or forces proper to the animal; or, in other words, to determine the laws according to which the qualitative and quantitative variations of the income affect the quantity and quality of the capital, and thence the quality and quantity of the expenditure. The practical problems for whose solution a knowledge of such laws is desirable will vary of course with the circumstances of the animal. For instance, in animals doomed to the slaughter-house the questions have to deal more particularly with the amount and nature of the material developed in the body, that is to say, with the amount and character of the capital. In man and beasts of burden attention has to be drawn to the amount and nature of the force expended, muscular, nervous, &c." The food, in the ordinary sense of the word, consists for the most part of more or less imperfectly oxidised proteinaceous and hydrocarbonaceous compounds; but as these by themselves are quite incapable of repairing and maintaining the animal economy, we cannot but extend its meaning so as to embrace that essential ingredient in the body's income, oxygen. In addition to these, there are some substances which some persons do not consider to be food, although they supply indirectly the place of food. Most of these act as regulators, chiefly in exciting or enabling those parts of the system which elaborate the food to perform the functions to better effect. In some cases these act within the system itself, but others seem to act almost exclusively outside the real body. Amongst the last may be mentioned the condiments, which become serviceable by promoting the secretion of saliva, and perhaps also the cooking of food, for there can be little doubt that the general result is more or less influenced by the mechanical condition of the food. Although much has been done in the way of analyses of food, and the comparative effects of ordinary diets on various classes of individuals, still we do not consider that science is in a position to enunciate what constitutes a normal healthy diet, since so much depends upon the conditions of each individual, and of the circumstances amidst which he lives. Thus, for instance, Dr. Smith recommended that the food of the Lancashire operatives, and we may add of able males in workhouses, should consist of common articles of consumption in such proportions that the food of each day shall contain 265 grammes of carbon and 12 grammes of nitrogen. This is what is termed a starvation diet, since it is the formulation result of analyses of the daily meals of needlewomen, silkweavers, and the poorest classes of workers, who can only just manage to keep off starvation. The agricultural labourer consumes a daily supply which contains 420 grammes of carbon and 20 grammes of nitrogen. These results can only be applied with any confidence to masses since they have been drawn from masses, and should not be applied too rigorously to individuals, since the variations from a standard even by persons in normal health are very wide. As examples, we give two illustrations from Dr. Carpenter, who mentions a miller that lived in good health for 18 years on food that yielded 110 grammes of carbon and 5·8 grammes of nitrogen per day. On the other hand, cases are known, amongst the Canadians, for example, of individuals who are not satisfied with less than 20 pounds of meat, which implies a consumption of 280 grammes of nitrogen. As it does not appear that persons who eat such enormous quantities of food are in any way remarkable for superiority of strength, or endurance, or mental activity, it is probable that a portion only of the food is really taken into the system itself. Hence we require to know, not how much aliment is introduced into the alimentary canal, but how much is ultimately incorporated with the tissues. It may frequently happen that a diet contains abundance of combined carbon and nitrogen to maintain vigour, and yet the circumstances either of the food or of the individual may not admit of a sufficiency being absorbed.

In an article by Mr. Foster cited below, the laws of nutrition are considered under the two heads of *Statics* and *Dynamics*, the former relating to the composition of the ingesta, tissues, and egesta, while the latter refers to the development of force. In order to show the general state of knowledge respecting the latter branch of the subject, we append Mr. Foster's remarks thereon:—"While the statical part of the subject is of course of most interest in reference to the nutrition of animals destined to be slaughtered for food, the dynamical part is of most importance when the nutrition of man is considered. What kind of food is best adapted for the development of muscular, what for nervous force? are the most fundamental problems of physiology. Previous to entering into detail, however, an inquiry should be made (if for nothing else, at least for the sake of justifying the assumption of the applicability of the conservation of force to the living frame) between the total income and the total expenditure of force. This will be most conveniently done by reducing both to units of heat. The determination of the total amount of force expended within a given time by an animal body is a comparatively easy task. For, diverse as are the various manifestations of force within the economy, they are all reduced, before they leave the body as an expended force, into two modes only, namely, heat and mechanical effect, the quantity leaving the body as electricity being probably exceedingly small. Thus all the various forces which we class together under the name of nervous force resolve themselves, after all their multitudinous wanderings and transformations, into heat, except the minute fraction which may be supposed to be carried on into muscular action, and so to find its exit as mechanical effort. Muscular action too loses itself partly as mechanical effect, but to a much greater amount probably as heat. All secretive or nutritive action, again, goes out as heat. Heat and mechanical movement are, in fact, the only true *effectus* of the animal body. Whatever does not go out in the one form, issues in the other. Two animals, living on the same food, and subject to the same metamorphosis, will rise to the same amount of actual energy; and yet in the one a large amount of that energy may assume the form of mechanical effect, while in the other, no muscular contraction being made, it nearly all goes out as mere heat, which, being dissipated, as soon as generated, causes no alteration in the animal's temperature. Hence, if we estimate the total mechanical effect of any animal during a given time, and the total amount of heat given off at the same time, we shall obtain the total amount of expended force. This may readily be done by placing an animal in a calorimeter with a treadwheel for determining the mechanical effect. By reducing the mechanical effect to units of heat, and adding them to the units of heat denoted by the calorimeter, we arrive at the total expended force estimated in units of heat. A calorimeter is doubtless not a proper home for an animal, and therefore probably the result of the experiment will not give accurately the normal expenditure of the natural animal, seeing how sensitive and responsive in all its parts is the animal economy to variations of temperature. Yet it cannot be far from the truth. The estimation of the total force of the income is a much more difficult task. The units of heat given off by the combustion of each article of food have to be determined, and from their sum total has to be deducted the number of units of heat still obtainable from the incompletely oxidized portion of the excreta belonging properly to the food in question. Unfortunately, this at present has not been accomplished. It has generally been deemed sufficient to calculate the latent energy of any alimentary substance from the units of heat given off by the combustion, in an uncombined state, of its carbon and free hydrogen. This, however, leads to a result which we may safely assume as being incorrect without knowing how far it errs from the truth. Hence the failure of Dulong and Despretz to obtain a balance between the actual heat given off by an animal during a given time, and the amount calculated as due to the quantity of carbon and hydrogen presumed to have been actually oxidised in the system during that time, cannot be regarded as any argument against the possibility of obtaining such a balance with great exactitude if more correct methods were employed. Using, however, such imperfect means in the absence of better ones, Helmholtz calculates that a man of 82 kilogrammes weight expends in 24 hours 2,700,000 units of heat, of which 2·6 per cent. goes to warming the food and drink; 2·6 per cent. to warming the air of respiration; 14·7 per cent. is lost in the evaporation of water through the lungs; the remainder, 77·5 per cent., being distributed over losses by urine and fæces, evaporation from skin, radiation and conduction from surface, and mechanical effect. Ludwig calculates the mechanical effect of a good day's work to be equivalent only to 220,930 units of heat. Still more difficult is the task of tracing backwards to the food, or onwards to the excreta, any of the special kinds of forces at work within the economy. To take for instance muscular force, as one of the simplest, it may be asked, which elements contribute solely or chiefly to its production, and which of the elements of the egesta may be taken as the index of its occurrence? The Rev. S. Haughton ('Dublin Quarterly Medical Journal,' 1859—60,), taking it for granted that the nitrogen of the urine or fæces represented the whole muscular or mechanical, nervous or mental, and nutritive or vital, work of the economy, while the remaining excreta answered to what he calls *opus calorificum*, made the following investigation:—Having determined the daily excretion *per anum et vesicam* of nitrogen reckoned as urea in a series of men of different bodily weights, performing different mechanical work, undergoing different mental labour, he was enabled to construct a series of equations, which he solved for certain values which it was desired to know. He thus calculated that 300 grains of urea represent the daily nutritive work of a man weighing 150 lbs.; that 136·5 grains of urea represent the muscular force required to lift 150 lbs. through one mile, a hard day's work; that 222 grains of urea represent the daily mental exertion of a man of business. It need hardly be said, however, that the assumptions on which these calculations are based are open to grave objections. In dealing with the statics of this subject, the word flesh was used to denote the total protein substance of the body. And it was only in this wide sense of the word that urea was considered as the result of the metamorphosis of flesh. It is true that Bischof and Voit use the same word flesh as synonymous with muscle, but such an assumption rests on no basis of facts. Although the nervous system in Bidder and Schmidt and Chossat's experiments seemed to suffer but little waste in inanition, we cannot for that reason conclude that during life it suffers little metamorphosis. On the contrary, it is impossible, with the general views by which we are judging the whole subject, to think otherwise than that where there is apparently so much production of force, there should also be much change. And as far as the changes in the nervous tissue simplicate the protein substance therein contained, they must be considered as giving rise to urea. In the liver again, in the glands, and in all the other organs which we may call the nutritive organs, we must also (in addition to the changes supposed, according to one theory, to occur in the digested food as it passes through or comes in connection with those organs in the blood current) suppose considerable, it might almost be said excessive, metamorphosis to take place, which, in so far as it is nitrogenous, will also produce urea. Hence the total amount of urea cannot be taken as the index of the metamorphosis of muscular tissue only. Nor can we fairly assume that even a large part of it is to be so regarded. It may be urged that muscular tissue forms so large a part of the total protein-substance of the body, that we have every reason to believe that it suffers great and rapid changes. But we possess no exact information as to how large a share in its metamorphosis is taken by the nitrogenous constituent alone; and, on the other hand, we are similarly ignorant of the intensity of the nitrogenous transformations in the other organs of the body. It is true that in muscular tissue we find creatine and creatinine, and there is some reason for believing that they (one or both) are increased during muscular contraction when metamorphosis is presumed to be increased; but the physiological connection between creatine or creatinine and urea has not yet been fully traced. On the contrary, there are not wanting facts indicating the closest bonds between urea and the liver. So marked indeed are they, that the action of the liver has been called in to assist the theory of luxus-consumption, on the idea that the changes taking place there belong, not exactly to the liver itself, but to the blood in the liver. On these points, however, our information is exceedingly imperfect. Physiologists perhaps err in being apt to regard the processes of the animal body as too simple, too straightforward. May not urea and carbonic acid be, not the result of a splitting up and facile oxidation, but the ends of long series of, perhaps backwards and forwards, changes, so that the point or place where each is first detected is not necessarily the place where the most important act of metamorphosis takes place? If it is difficult to connect urea in any special manner with the metamorphosis of muscular tissue, it is still more difficult to connect it with the exhibition of muscular force. If urea were the most important product of muscular metamorphosis, and muscular metamorphosis the most important source of urea, then since, during muscular contraction, the metamorphosis of muscular substance is presumed, on apparently satisfactory grounds, to be largely increased, the amount of urea ought to be largely increased by muscular exertion. It is true that under this view there will always be in the urine a tolerably large constant quantity of urea due to the amount of muscular exertion, employed in visceral movements, which varies only within comparatively narrow limits. But such an amount must be fully overpowered by an excess of urea due to violent and long continued exercise. Observations (Smith, Voit, Speck, and Lehmann) on the effect of muscular exertion on the excretion of urea are not unanimous. Yet, even when allowance is made for retention, that is, for decrease of elimination as compared with decrease of formation, the conclusion may fairly be drawn that exercise even carried to exhaustion produces an increase of urea too small to be regarded in any way as the equivalent of the expended muscular force. At the same time observers are equally agreed that muscular exertion does produce a very large increase in the carbonic acid of the egesta. So clearly did this come out in the experiments of Dr. E. Smith, that that gentleman believes himself justified in recommending an addition of carbon to the food when bodily exertion is called for. It has been urged that Voit and others, by simply estimating the urea (with uric acid, &c.,) in their experiments, have left open the possibility of other nitrogenous bodies being present in large quantities on such occasions, and on such occasions only, in the urine. But these hypothetical bodies have never been detected, and the possibility of their existence does not negative the fact of the increase in the carbonic acid. It must be remembered, however, that there is in the living muscle, even when perfectly at rest, an active metamorphosis still going on, resulting in part as electricity, but finally as heat. Perhaps even during the very act of contraction (as distinguished from the conditions immediately preceding and following) there is not so much an increase of metamorphosis as a change in the direction or form into which the energy, set free by the metamorphosis, is converted. If so, the carbonic acid would be only indirectly, and the urea not at all, an index of the amount of expended force, while the total metamorphosis of the muscular system would measure possibilities of action rather than actual achievements. When we reflect that the animal body, considered as a working machine, is characterised by being subject to sudden calls for action from every quarter, it will be easily understood that the best state of preparation for emergencies is not one in which there is a mere store of latent energy, but one in which force is continually being liberated, and therefore ready at a moment's notice to be turned in any particular direction, or converted into any particular form. This of course implies that for every mechanical effect a large amount of force is spent in a non-mechanical manner, and therefore apparently lost. But so abundant are the resources of the economy for the using up of this wasted force, that, according to Helmholtz, while the best steam-engine loses nine-tenths of the total power of its fuel, the human body is able to convert into mechanical effect one-fifth of the total power of its food. Urea then cannot be taken safely as a measure of mechanical work done by the body: with still less safety perhaps can it be taken as a measure of the mental work. And as it is impossible at present to trace the various members of the egesta back to the various forms of vital force, so it is impossible to trace the latter to the various constituents of food. If one general view of the whole vital processes can be regarded as more likely than another, it is perhaps the idea that the brute force of the economy, so to speak, is represented by the carbon (and hydrogen) of its food, while the nitrogen is more closely concerned with internal changes by which that brute force is converted into the many varieties of vital energy. Playfair argues that only the nitrogenous elementary principles are concerned in the production of muscular (and mental ?) force, and gives calculations showing that the latent energy of such an albuminous diet as is usually consumed by active labourers is sufficient to account for the actual force, both of the internal muscular movements and of the external useful work of an ordinary man. But Carpenter has made calculations which lead to an exactly opposite conclusion; and Haughton's equations, so far as they can be trusted, tend to support the view that the force of muscular action is derived in part at least from the hydrocarbon or carbo-hydrates of food. So long as the present uncertainty about the latent energy of complex substances continues, and so long as the evolution of heat is not observed at the same time that the mechanical force is estimated, all questions of dynamics must remain obscure."

This subject of the source of muscular power and of nutrition of the muscular tissue, has been examined by numerous other writers. Amongst the most recent are Messrs. Frankland, Fick, and Wislicenus. The account of their researches will be found in the 'Philosophical Magazine,' vol. xxxi. p. 485; and 'Proc. Roy. Instit. of Great Britain, for 1866.' For details we must refer to the memoirs, but the conclusions arrived at by Dr. Frankland are as follows: (1) The muscle is a machine for the conversion of potential energy into mechanical force. (2) This force is derived wholly or mainly from the oxidation of blood, not of muscle, material. (3) In man the material usually oxidised is of a non-nitrogenous nature, but nitrogenous can be used. (4) The muscles undergo constant interstitial metamorphosis, but the rate does not vary greatly whether the muscle be in rest or in action. (5) The tissues are mainly repaired by albuminous substances, and when the tissues are in good condition the best materials for producing mechanical force are such non-nitrogenous substances as oil, fruit, sugar, starch, gum. (6) All the energy of the non-nitrogenous matter which enters the blood is used up, but only about one-seventh of that of the nitrogenous bodies. (7) Heat always accompanies the conversion of potential energy into muscular power.

Although the labyrinths of nutritional inquiry have been very insufficiently explored, the present state of the research impresses one with their complexity, and tends to convince the student that it is reducible to precisely calculable laws. When those laws have been discovered it will be practicable to formulate the acts of humanity and of all animals by definite phrases and figures, and to show how, as in the machine, the result is producible from the application of a known force in a given way. The laws of nutrition will be powerful aids to the classifier, as also to him who is endeavouring to unravel the mysteries of the evolution of the individual, or of the species, or of organisms generally. The laws of nutrition applied to zoology, will convert the aspect of that science into one very different from the present. Now, zoologists are excessively descriptive; they see little more than the machine when not in action, and concentrate their attention on the form and grouping of parts; but when a consideration of the laws of nutrition becomes an important feature in their study, they will show us how the wheels of the mechanism work. Then, and the time is perhaps still far off, then we shall be able to appreciate the influence of external circumstances, that is, of groupings of forces and matter outside the animal itself, in modifying the working of the animal machine, the arrangement of its parts, and the resultant manifestation of force and intellectuality.

(Carpenter, *Principles of Human Physiology*, 6th edition; Foster, in *Watts' Dictionary of Chemistry*, Art. '*Nutrition*.'

O

OLD RED SANDSTONE [E. C. vol. iv. cols. 78—80], a series of strata which are well developed in the northern parts of Great Britain, and which have been graphically described by Hugh Miller. It has a more varied lithological character than its name would imply, and consists of limestones, marls, sandstones, grits, conglomerates, and shales, of a great variety of tints, red and purple being the most prevalent. These strata are, as has already been indicated in E. C., believed to be the representatives of the Devonian strata proper deposited under a different set of circumstances. The Devonian strata overlie the silurian formation, and pass upwards into beds of the carboniferous series. The lowest beds of the old red sandstone are conformable with the highest silurian beds of some areas, as in South Wales; while in other areas, such as Central Scotland, the highest beds have the same strike and dip as the carboniferous series above them. Further, a transition between the upper portions of the old red sandstone and Devonian has been traced in South Wales by Mr. Salter [DEVONIAN FORMATION, E. C. S.]. But although there is unquestionably a general similarity in stratigraphical position, there is a marked dissimilarity in the respective faunas of the two systems of strata. There are very few species common to the two series, and still fewer genera; while all the classes represented in the old red sandstone are such as now embrace both fresh water and marine species. This apparent absence of all the exclusively marine classes is perhaps the most instructive feature of the old red sandstone fauna. There are also marked differences in the lithological character of the strata. For example, conglomerates are rare or absent in the Devonian beds of England; while conglomerates are sometimes developed to an enormous thickness in the old red sandstone. Again, the prevalence of red tints in the old red sandstone is a feature which, although by no means peculiar to the old red sandstone, is nevertheless a character by which its upper and lower boundaries are sometimes distinguished.

The peculiar feature of this group of beds has been, and indeed still is, a puzzle to the geologist; for if the fauna has not that decidedly marine character which prevails in the typical Devonian strata, how is it we do not find more abundant traces of terrestrial plants and relics of air-breathing creatures? Some persons have suggested that these peculiar beds indicate an area which was largely lacustrine, and although there is very slight analogy between the old red fauna and that which we should expect as representative of the lake life of the period, yet there are not a few considerations seemingly in favour of such views, which cannot, however, be cited in support of them. Thus he who has followed Murchison in his comprehensive outline of the area of the pre-existing silurian seas, and has thus been led all across the high northern latitudes of Europe and America, and round by Bohemia and Spain, is readily impressed with the general absence of evidence of any large tract of land during that period, at any rate, during the earlier portion of it. He who has carefully studied the distribution of the old red sandstone must recall to mind numerous instances in the north and south of Europe, as also in America, in which these sandstones, or their marine representatives, the Devonian strata, rest unconformably upon lower silurian beds; he will remember how general the old red conglomerates are, which serve to indicate sometimes the contiguity of land, but more frequently its actual boundaries. Thus in England they surround silurian islands; in Scotland they form a sinuous margin along the flanks of the metamorphic hills; in Ireland, a conglomerate can be traced from Wicklow on the east, far away into the west. Similar facts might be recorded from other countries, the tendency of which is to show that land must have been far more abundant in Devonian than silurian times. These conglomerates have further afforded certain appearances, which, if they have been correctly interpreted, would confirm the existence of a large polar or northern continent in the northern hemisphere. In many places they are composed of large sub-angular blocks, frequently more than two feet in length, which cannot be traced to any of the rocks of the immediate neighbourhood. They are sometimes confusedly arranged and embedded in a sandy or clayey basis, and in a few localities, such as Great Dove Cote Gill near Sedbergh, the pebbles have presented striated surfaces, such as strangely recall to mind the striated pebbles of the far later glacial epoch. Considerations such as these have suggested the question whether glaciers existed during the Devonian epoch. They appear to be of sufficient importance to warrant the putting of the question; but they are far from sufficient to settle it either affirmatively or negatively.

Although the fauna of the old red sandstone is so different from that of the Devonian strata, yet its peculiar features suggest that those two series are more or less contemporaneous. We should expect that the thousands of feet of old red sandstone, with its ill-developed marine fauna, would be represented somewhere by a series of beds in which the marine character of the fauna is as decided as in the earlier silurian and later carboniferous formations; and the strata of Devonshire have this required character [Devonian Formation, E. C. S., cols. 347—368]. But admitting that these two series of beds were deposited in the interval between the latest silurian and earliest carboniferous strata in Great Britain, or even in western Europe, the facts seem to be too few and undecisive to warrant the correlation of the lower, middle, and upper Devonian with the lower, middle, and upper old red sandstone. The upper old red sandstone may be equivalent in time to the upper Devonian, but there is nothing to show that the lower two divisions of each correspond. The lower old red sandstone is far more nearly related stratigraphically and palæontologically to the upper silurian than the lower Devonian; although there is apparently a greater similarity in the circumstances under which the lower Devonian and upper silurian strata were deposited. Very few species pass from silurian into Devonian beds; and on this ground, taken in connection with the nature of the strata, it may be more safe to suppose that the beds which were formed after the Downton and before the Lynton sandstone were of considerable rather than inconsiderable thickness. Sir Charles Lyell, Sir Roderick Murchison, Mr. Pengelly, and other eminent geologists, assent to the correlation of the three divisions of each of the formations under notice. Sir C. Lyell's views may be indicated thus:—

Upper Devonian.—Yellow sandstone, of Dura Den with *Glyptolaemus*, and of Kilkenny with fossil fish. Pilton group of north Devon with *Spirifer disjunctus*. Petherwyn group of Cornwall with *Clymenia* and *Cypridina*.

Middle Devonian.—Sandstones of Forfarshire and Perthshire, with *Holoptychius*. Bituminous schists of Gamrie, Caithness, &c., with numerous fish. Unfossiliferous series of North Devon. Ilfracombe beds, with many trilobites and corals, and with *Cephalopoda* distinct from upper Devonian species.

Lower Devonian.—Arbroath paving-stones with *Cephalaspis*, *Pterygotus*, and *Parka*. Lower sandstones of Caithness with *Pterygotus*. Sandstones and slates of the Foreland and Lynton. Sandstones of Torquay with broad-winged *Spirifers*.

As a fuller illustration of his views we quote his account of the old red sandstone of Scotland, south of the Grampian Hills. He recognises three groups, which are denoted by A, B, and C; which correspond to what are called lower, middle, and upper, in the foregoing paragraph.

A. The upper member, or yellow sandstone, is seen at Dura Den, near Cupar in Fife, immediately underlying the coal. It consists of a yellow sandstone, in which fish of the genera *Pterichthys*, *Pamphractus*, *Bothriolepis*, *Glyptopomus*, *Holoptychius*, and others abound. In Ireland the upper beds of the old red, or yellow sandstone of Kilkenny, contain fish of the genera *Coccosteus* and *Dendrodus*, characteristic forms of this period, together with plants specifically distinct from any known in the coal measures, but referable to the genera found in them, as for example, *Lepidodendron*, *Cyclopteris*. The stems of the latter have, in some specimens, broad bases of attachment, and may therefore have been tree ferns. In the same strata, shells having the form of the genus *Anodon*, and which probably belonged to fresh water testacea, occur. Some geologists, it is true, still doubt whether these beds ought not rather to be classed in the lowest of the carboniferous series, together with the yellow sandstone of Sir R. Griffiths; but the associated ichthyolites, and the distinct specific character of the plants, strongly favour the view above expressed. B. We come next to the middle division of the "Old Red," as exhibited south of the Grampians, and consisting of—1st, red shale and sandstone, with some cornstone, occupying the valley of Strathmore, in its course from Stonehaven to the Firth of Clyde; and 2ndly, of a conglomerate, seen both at the foot of the Grampians, and on the flanks of the Sidlaw Hills. In the uppermost beds, the scales of a large ganoid fish, of the genus *Holoptychius*, were first observed by Dr. Fleming at Clashbinnie, near Perth, and an entire specimen, more than two feet in length, was afterwards found by Mr. Noble. Some of these scales measured 3 inches in length, and 2½ in breadth. C. The third, or lowest division south of the Grampians, consists of grey paving-stone and roofing slate, with associated red and grey shale; these strata underlie a dense mass of conglomerate. In these grey beds several remarkable fish have been found of the genus named by Agassiz, *Cephalaspis*, or 'buckler-headed,' from the extraordinary shield which covers the head, and which has often been mistaken for that of a trilobite such as *Asaphus*.

A large proportion of the fossils of the old red sandstone are fishes, as will be seen from the subjoined list. These have been described in decade x. of the 'Geological Survey Memoirs,' by Prof. Huxley and Sir P. Egerton. They belong chiefly to the *Crossopterygidæ*, or fringe-finned group of ganoids, represented in the living fauna by the *Polypterus* of Africa. In the list of species we have inserted the letters L. M. U. to indicate their occurrence in the Lower, Middle, and Upper divisions: the ranges being those given by Mr. Etheridge. We may mention that Mr. Etheridge's sub-divisions correspond with those adopted by Sir C. Lyell.

List of Species found in the Old Red Sandstone of Great Britain.

(*From Q. J. Geog. Soc. XXIII., p.* 616, *et seq.*)

Plantæ.
Caulopteris Peachii. Salt. M.
Lepidodendron nothium. Ung. M.
Knorria dichotoma. Haught. U.
Pachytheca sphærica. Hooker. U.
Adiantites hibernicus. Forbes. U.
Lycopodites Milleri. Salt. M.
Sagenaria veltheimiana. Sternb. U.
S. Kiltorkensis. Haugh. U.
Bornia transitionis. Göpp. U.
Sphenopteris sp. U.
Filicites lineatus. U.
Trichomanites adnescens. Göpp. U.
Annelida.
Serpula advena. Salt. U.
Tentaculites scalaris. Schlott. L.
Crustacea.
Campicaris forfarensis. Page. L.
Estheria membranacea. Pacht. L. M.
Eurypterus abbreviatus. Salt. U.
E. acuminatus. Salt. L. U.
E. Brewsteri. Powrie. L.
E. megalops. Salt. L.
E. Scouleri. Hibbert. U.
E. pygmaeus. Salt. L.
Parka decipiens. Page. L. U.
Leperditia marginata. Jones. L.
Pterygotus anglicus. Ag. L.
P. minor. H. Woodw. L.
P. Brewsteri. Powrie. L.
P. problematicus. Salt. L.
Stylonurus Logani. Woodw. L.
S. punctatus. Salt. L.
S. ensiformis. Woodw. L.
S. scoticus. Woodw. L.
S. Symondsii. Salt. L.
S. Powriei. Page. L.
S. megalops. Salt. L. U.
Polyzoa.
Berenicea M'Coyii. M.
Lamellibranchiata.
Anodon Jukesii. Forbes. U.
Pisces.
Acanthodes pusillus. Ag. M.
A. Peachii. Egert. M.
A. coriaceus. Egert. M.
A. Mitchelli. Egert. L.
Actinolepis tuberculatus. Ag. M. U.
Asterolepis Asmusii. Ag. M.
A. Malcolmsii. Ag. M. U.

Asterolepis minor. Ag. U.
Auchenaspis Salteri. Egert. L.
A. ornatus. Egert. L.
Bothriolepis favosus. Ag. M. U.
B. ornatus. Eichw. M. U.
Brachyacanthus scutiger. Egert. M.
Byssacanthus arcuatus. Ag. L.
Cephalaspis asterolepis. Huxl. L.
C. Lewisii. Ag. L.
C. Lyellii. Ag. L.
C. Murchisoni. Ag. L.
C. solwayi. Egert. L.
C. ornatus. Egert. L.
Cheiracanthus grandispinis. M'Coy. M.
C. latus. Egert. M.
C. microlepidotus. M'Coy. M.
C. minor. Ag. M.
C. Murchisoni. Ag. M.
C. pulverulentus. M'Coy. M.
Chirolepis Cummingiæ. Ag. M.
C. Traillii. Ag. M.
C. uragus. Ag. M.
C. velox. M'Coy. M.
Climatius reticulatus. Ag. L.
C. scutiger. Egert. L.
C. uncinatus. Egert. L.
Coccosteus cuspidatus. Ag. M.
C. decipiens. Ag. M.
C. maximus. Ag. M.
C. Milleri. Egert. M.
C. oblongus. Ag. M.
C. minor. Mill. M.
Conchodus ostreiformis. M'Coy. M.
Cosmacanthus Malcolmsonii. Ag. M.
Ctenacanthus ornatus. Ag. L.
Ctenoptychius priscus. Ag.
Dendrodus incurvus. Duff. M.
D. latus. Owen. M.
D. sigmoideus. Owen. M.
D. strigatus. Owen. M.
Diplacanthus crassispinus. Ag. M.
D. gibbus. M'Coy. M.
D. longispinus. Ag. M.
D. perarmatus. M'Coy. M.
D. striatus. Ag. M.
Diplopterus affinis. Ag. M.
D. Agassizi. Traill. M.
D. borealis. Ag. M.
D. macrocephalus. Ag. M.
Dipterus macrolepidotus. Sedg. L. M.
Euthacanthus MacNicoli. Powric. L.
Glyptolepis elegans. Ag. M.
G. leptopterus. Ag. M.
G. microlepidotus. Ag. M.
Glyptopomus minor. Hux. U.
Glyptolaemus Kinnairdi. Huxl. U.
Gyroptychius angustus. M'Coy. M.
G. diplopteroides. M.
Holoptychius Andersoni. Ag. U.
H. giganteus. Ag. M.
H. Murchisoni. Ag. M.
H. nobilissimus. Ag. M. U.
H. Sedgwickii. Ag. M.
Homothorax Flemingii. Ag. U.
Ischnacanthus gracilis. Egert. L.
Lamnodus biporcatus. Owen. M.
L. Panderi. Ag. M.
L. sulcatus. Ag. M.
Onchus arcuatus. Ag. L.
O. semistriatus. Ag. L.
O. ? Murchisoni. ? Ag. L.
Osteolepis arenatus. Ag. M.
O. brevis. M'Coy. M.
O. macrolepidotus. Ag. M.
O. major. Ag. M.
Pamphractus Andersoni. Ag. U.
Parexus incurvus. Ag. L.
Phaneropleuron Andersoni. Hux. U.
Phyllolepis concentricus. Ag. L. M.
Placothorax paradoxus. Ag. M.
Plathygnathus Jamesoni. Ag. U.
P. paucidens. Ag. M.
Pterichthys cancriformis. Ag. M.
P. cornutus. Ag. M.
P. hydrophyllus. Ag. U.
P. latus. Ag. U.
P. major. Ag. M.
P. Milleri. Ag. M.
P. macrocephalus. Egert. U.
P. oblongus. Ag. M.
P. productus. Ag. M.
P. quadratus. Egert. M.
P. testudinarius. Ag. M.
Pteraspis Banksii. Hux. L.
P. dunensis. Hux. L.
P. Lloydii. Ag. L.
P. rostratus. Ag. L.
Pteraspis Mitchellii. Powrie. L.
P. truncatus. Hux. L.
Ptychacanthus dubius. Ag. L.
Tripterus Pollexfeni. M'Coy. M.
Tristichopteris alatus. Egert. M.

It is a disputed question at present whether reptiles lived during this period or not. In Elgin county there are a series of sandstones which overlie what are admitted to be old red sandstone strata, and from which it is difficult to separate them stratigraphically, since the newer sandstones are conformable to the lower beds, having precisely the same dip. At the base of the higher sandstones there is a conglomerate which may or may not indicate a great stratigraphical break. Prof. Harkness and other geologists believe all the beds belong to one period, viz., the old red sandstone. Few fossils have been discovered in the higher sandstones, but amongst them are the reptilian genera —*Telerpeton*, *Stagonolepis* and *Hyperodapedon*. It is mainly from the presence of these forms that many geologists feel reluctant to admit the old red sandstone age of these beds; and by most it is suggested they are of triassic date, although there is no conclusive evidence to show this. Several specimens of *Hyperodapedon* have been discovered, and, if as we believe is the case, all belong to the same species *H. Gordoni*, this will go far to indicate that these sandstones are really triassic and not Devonian. For this species has been discovered in the triassic beds of Warwickshire, in the upper trias of South Devon, and in beds which are assigned to the triassic age in Central India. In the case of the Warwickshire and Devonshire specimens there is no disputing the post-carboniferous age of the beds in which they were entombed, and it is not likely that the same species of reptile lasted from Devonian to triassic days.

ORCHIDACEÆ [E. C. vol. iv. col. 111—114]. This vast order, the members of which are still eagerly cultivated by many admirers of their extraordinary shapes, gorgeous hues, and manifestations of coadaptation of structure for special purposes, is now represented by upwards of 6000 reputed species. Some of the principal florists have travellers in various parts of the globe almost solely employed in the search for these plants, some of the scarcer and more difficult species of which are prized so highly as to be saleable at the rate of from five to ten guineas for each individual. On one occasion we were assured that some two or three hundred new species were received in the course of a single year. This statement is probably true, if we take the same view of a species as a practical gardener does, whose trained eye readily seizes differential details, and whose interest it is to recognise as many species as possible. A few botanists, whose delight it is to make species rather than to discover natural laws, would probably coincide with the gardeners. However this may be, we consider that the true average rate of discovery of new reputed species is about one hundred per year.

In the original article attention was drawn to the curious mimetic resemblance observable in the arrangement of the floral organs. In the present article we shall chiefly refer to the connection which such arrangement has in providing for the fertilization of the flower, and upon the important share which insects have in ensuring this object. The flowers of orchids, however various their shape, appear to be formed of fifteen primordially distinct organs; but this number is frequently reduced in appearance through the confluence of some, and the abortion or rudimental development of others. Each part acquires a special form, size, and relative position in each species, and in each functional modification of a species. Whatever modification may occur it never reverses the position of the parts relatively to the central axis of the flower, by which we mean that the order from the centre is always conformable to the following arrangement, the innermost being named first, viz., three pistils or female organs, six anthers in two circles or whorls, three petals and three sepals. The number of parts developed may vary, but the order from within is invariably pistils, anthers, petals, and sepals. The modifications are brought about by the coalescence of one or more organs in each circle, or of contiguous circles; and by the unequal development of the organs.

The three female organs or pistils usually terminate in viscid surfaces; two of these form the stigmas, and are nearly always at a lower level than the third. This last finally becomes detached from its main stem, and contracts adhesion with the stalk or caudicle supporting the agglomerated pollen grains. Here then we have coalescence of the stigmatic surface of the third pistil with the pollen grains of an anther; this compound mass is designated a *pollinium*, and the viscid disc a *rostellum*. The third stigma, or that which developes the rostellum, has, as will be seen, lost its fertility, but like the neuters amongst insects, it helps indirectly towards the fertilization of the seed. The close contiguity of the pollen grains and the stigmas in the same flower was at one time regarded as a special arrangement to secure self-fertilization, but from the researches of Mr. Darwin it is manifest that the parts are, in the great majority of species, so adapted as to necessitate the habitual fertilization of one plant by the pollen grains from another, that only a few instances are known in which the crossing is occasional, and probably there is no well-established case in which an hermaphrodite fertilizes itself for a perpetuity of generations. Another fact which has been well illustrated by Darwin's experiments, is that as a rule, applicable to most species, orchids are incapable of transferring the pollen from the anthers to the stigmas, this operation being effected by some external force. In a few species the wind is the moving agent, but in the great majority insects effect the transference. The few motions which the orchids themselves perform in furtherance of the final object are surprisingly like some of the actions which naturalists are in the habit of terming instinctive in animals. The whole series of motions which make up the complete action is so varied in the numerous species of orchids, and so full of admirable design, as to elicit from Darwin the observation that it "transcends in an incomparable degree the contrivances and adaptations which the most fertile imagination of the most imaginative man could suggest with unlimited time at his disposal." These contrivances are so numerous that we cannot give a full idea of them, but as one example we give Darwin's graphic description of the fertilization of *Orchis pyramidalis*, "one of the most highly organized species which I have examined, and which is ranked by several botanists in a distinct genus. The relative position of the parts is here considerably different from what it is in *O. mascula*, and its allies. There are two quite distinct rounded stigmatic surfaces placed on each side of the pouch-formed rostellum. This latter organ, instead of standing some height above the nectary, is brought down so as to overhang and partially to close its orifice. The ante-chamber to the nectary, formed by the union of the edges of the labellum to the column, which is large in *O. mascula* and its allies, is here small. The pouch-formed rostellum is hollowed out on the under side in the middle; it is filled with fluid. The viscid disc is single, of the shape of a saddle, carrying on its nearly flat top or seat the two caudicles of the pollinia; of which the two truncated ends firmly adhere to its upper surface. Before the membrane of the rostellum ruptures, it can be clearly seen that the saddle-formed disc forms part of the continuous surface of the rostellum. The disc is partially hidden and kept damp (which is of great importance) by the largely over-folded basal membranes of the two anther cells. The upper membrane of the disc consists of several layers of minute cells and is therefore rather thick; it is lined beneath with a layer of highly adhesive matter, which is formed within the rostellum. The single saddle-formed disc strictly answers to the two minute oval separate discs of membrane to which the two caudicles of *O. mascula* and its allies are attached; two separate discs have become completely confluent. When the flower opens and the rostellum has become symmetrically ruptured either from a touch or spontaneously (I know not which), the slightest touch depresses the lip,—that is, the lower and bilobed portion of the exterior membrane of the rostellum, which projects into the mouth of the nectary. When the lip is depressed, the under and viscid surface of the disc, still remaining in its proper place, is uncovered, and is almost certain to adhere to the touching object. Even a human hair, when pushed into the nectary, is stiff enough to depress the lip or pouch; and the viscid surface of the saddle adheres to it. If, however, the lid be touched too slightly, it springs back and re-covers the under side of the saddle. The perfect adaptation of the parts is well shown by cutting off the end of the nectary, and inserting a bristle at that end; consequently, in a reversed direction to that which nature intended moths to insert their probosces, and it will be found that the rostellum may easily be torn or penetrated, but that the saddle is never caught. When the saddle, sticking to a bristle, together with its pollinia, is removed, the under lip instantly curls closely inwards, and leaves the surface of the nectary more open than it was before; but whether this is of any real use to moths which so frequently visit the flowers, and consequently to the plant, I will not pretend to decide. Lastly, the labellum is furnished with two prominent ridges, sloping down to the middle, and expanding outwards like the mouth of a decoy; these ridges perfectly serve to guide any flexible body, like a fine bristle or hair, into the minute and rounded orifice of the nectary, which, small as it is, is partly choked by the rostellum. This contrivance of the guiding ridges may be compared to the little instrument sometimes used for guiding a thread into the fine eye of a needle. Now let us see how these parts act. Let a moth insert its proboscis (and we shall presently see how frequently the flowers are visited by *Lepidoptera*) between the guiding ridges of the labellum, or insert a fine bristle, and it is surely conducted to the minute orifice of the nectary, and can hardly fail to depress the lip of the rostellum; this being effected, the bristle comes in contact with the now naked and sticky under surface of the suspended saddle-formed disc. When the bristle is removed, the saddle with the attached pollinia is removed. Almost instantly, as soon as the saddle is exposed to the air, a rapid movement takes place, and the two flaps curl inward and embrace the bristle. When the pollinia are pulled out by their caudicles, by a pair of pincers, so that the saddle has nothing to clasp, I observed that the tips curled inwards so as to touch each other in nine seconds, and in nine more seconds the saddle was converted by curling still more inwards into an apparently solid ball. The probosces of the many moths which I have examined, with the pollinia of this *Orchis* attached to them, were so thin that the tips of the saddle just met on the under side. Hence a naturalist, who sent me a moth with several saddles attached to its proboscis, and who did not know of this movement, very naturally came to the extraordinary conclusion that the moth had cleverly bored through the exact centres of the so-called sticky gland of some orchid. Of course this rapid clasping movement helps to fix the saddle with its pollinia upright on the proboscis, which is very important; but the viscid matter rapidly setting hard would probably suffice for this end, and the real object gained is the divergence of the pollinia. The pollinia being attached to the flat top or seat of the saddle, project at first straight up, and are nearly parallel to each other; but as the flat top curls round the cylindrical and thin proboscis, or round a bristle, the pollinia necessarily diverge. As soon as the saddle has clasped the bristle and the pollinia have diverged a second movement commences, which action, like the last, is exclusively due to the contraction of the saddle-shaped disc of membrane. This second movement is the same as that in *O. mascula* and its allies, and causes the divergent pollinia, which at first projected at right angles to the needle or bristle to sweep through nearly 90 degrees towards the tip of the needle, so as to become depressed, and finally to be in the same plane with the needle. In these specimens this second movement was effected in from thirty to thirty-four seconds after the removal of the pollinia from the anther cells, and therefore in about fifteen seconds after the saddle had clasped the bristle. The use of this double movement becomes evident if a bristle with pollinia attached to it, which have diverged and become depressed, be pushed between the guiding ridges of the labellum into the nectary of the same or another flower; for the two ends of the pollinia will be found to have acquired exactly such a position that the one strikes against the stigma on one side, and the end of the other strikes against the stigma on the opposite side. These stigmas are so viscid that they rupture the elastic threads by which the packets of pollen are bound together; and some dark green grains will be seen, even by the naked eye, remaining on the two white stigmatic surfaces. I have shown this little experiment to several persons, and all have expressed the liveliest admiration at the perfection of the contrivance by which this orchid is fertilised. As in no other plant, or indeed in hardly any animal, can adaptations of one part to another, and of the whole to other organised beings widely remote in the scale of nature, be named more perfect than those presented by this *Orchis*, it may be worth while briefly to sum them up. As the flowers are visited both day and night by *Lepidoptera*, I do not think it fanciful to believe that the bright purple tint (whether or not specially devoted for this purpose) attracts the day-fliers, and the strong foxy odour the night-fliers. The upper sepal and two upper petals form a hood, protecting the anther and stigmatic surfaces from the weather. The labellum is developed into a long nectary, in order to attract *Lepidoptera*, and we shall presently give reasons for suspecting that the nectar is purposely so lodged that it can be sucked only slowly (very differently from what obtains in most flowers of other families), in order to give time for the curious chemical quality of the viscid matter on the under side of the saddle setting hard and dry. He who will insert a fine and flexible bristle into the expanded mouth of the sloping ridges in the labellum will not doubt that they serve as guides; and that they effectually prevent the bristle or proboscis from being inserted obliquely into the nectary. This circumstance is of manifest importance, for if the proboscis were inserted obliquely the saddle-formed disc would be attached obliquely, and after the compounded movement of the pollinia they could not strike the two lateral stigmatic surfaces. Then we have the rostellum partially closing the mouth of the nectary, like a trap placed in a run for game; and the trap so complex and perfect, with its symmetrical lines of rupture forming the saddle-shaped disc above, and the lip of the pouch below; and lastly, this lip so easily depressed, that the proboscis of a moth could hardly fail to uncover the viscid disc, and adhere to it. But if this did fail to occur, the elastic lip would rise again, and recover and keep damp the viscid surface. We see the viscid matter within the rostellum attached to the saddle-shaped disc above, and surrounded by fluid, so that the viscid matter does not set hard till the disc is withdrawn. Then we have the upper surface of the saddle, with its attached caudicles, also kept damp within the base of the anther cells, until withdrawn, when the curious clasping movement instantly commences, causing the pollinia to diverge, followed by the movement of depression, which compounded movements are exactly fitted to cause the two pollinia to strike the two stigmatic surfaces. These stigmatic surfaces are sticky enough not to tear off the whole pollinium from the proboscis of the mouth, but by rupturing the elastic threads to secure a few packets of pollen, leaving plenty for other flowers. But let it be observed that, although the moth probably takes a considerable time to suck the nectar of any one flower, yet the movement of depression in the pollinia does not commence (as I know by trial) until the pollinia are fairly withdrawn out of their cells; nor will the movement be completed and the pollinia be fitted to strike the stigmatic surfaces, until about half a minute has elapsed, which will give ample time for the moth to fly to another plant, and thus effect a union between two distinct individuals. Lastly, we have the wonderful growth of the pollen tubes and the penetration of the stigma, as well as the mysteries of germination, though these are common to all phanerogamic plants." The reference to remarks on the visits of Lepidopterous insects to orchid blossoms is fulfilled in his account of another species of *Orchis*, viz., *O. ustulata*. The cases in which insects have been actually seen to frequent such flowers are remarkably few as compared with what we should expect. Darwin himself had watched orchids for twenty years, and had only seen two butterflies sucking the blossom. Next to seeing the act, the most direct evidence is the occurrence of pollinia on the probosces or other parts of the body of *Lepidoptera*. This circumstance has doubtless been observed, but without its importance or meaning being recognized, by many observers. Thus Ménière stated in 1854, that a bee-keeper complained that his bees visited his neighbour's garden, and on returning from thence had their heads so covered with yellow bodies as to be unable to free themselves from them. These bodies were pollinia. It appears that at least twenty-three species of *Lepidoptera* visit the single species, *O. ustulata*, but it is not unlikely they frequent other species also. As yet observations have not been sufficiently numerous or precise to enable us to say what species of insects visit what species of orchids; nor whether it is usually the case that an orchid depends upon a single species of insect for its fertilization. Darwin thinks it probable that all the orchids with spear-like nectaries are visited indifferently by many kinds of moths; and that those which have not tubular nectaries are frequented by other orders. A third method of observation indicative of the extent of insect agency is afforded by an examination of the plants themselves, and estimating the number and proportion of pollinia which have been removed.

But there are many ways in which insects are pollen-carriers other than that just noticed with reference to *Orchis pyramidalis*, in which they are almost compelled to carry the pollinia on their probosces. Our space forbids our citing many examples. One is afforded by the fine exotic orchid, *Catasetum saccatum*. In it the column with its anther, pollinia, and stigmatic surfaces, stands upright, and the labellum stands out at right angles thereto. In the front of the column, and at about the middle, is an arched recess or stigmatic chamber. The arch of the recess is partially filled with the rostellum, the viscid surface of which is applied against the roof of the stigmatic chamber. The outer surface of the rostellum is covered by a membrane, and from this proceeds in a strong upward semi-elliptical curve, the pedicle which supports the pollen mass. The sides of the stigmatic chamber are prolonged into two filaments, one of which hangs down with its lower end curved inwardly; while the other stands out obliquely, so that its lower end, which is curved forward, occupies a median position. This filament is just long enough to project slightly over a depression in the labellum. This depression is very deep, and is apparently frequented by insects. In order to get at it they are almost compelled to proceed along a ridge, and in so doing they can hardly avoid touching the forwardly curved end of the filament. A gentle touch on this organ suffices to cause the pollinium to liberate itself from its attachment, and to straighten itself with such force as to project the pollinia with the heavy viscid end foremost to a distance of from one to three feet. Persons have touched the flowers of plants of this genus, and have received a shower of pollinia in their faces; and Darwin touched the filaments of a plant of *Catasetum callosum*, when the pollinium hit and adhered to a window pane a yard off. It does not appear how the fertilization is aided by the pollen masses being projected so straightly forward; but the case becomes clearer when it is considered that the exciting object is probably a large insect, and that such an object would be placed so near the anther, as to be accurately struck in the middle by the projected pollinium, and as the viscid disc is forwards this would cause the mass to adhere to its back. The strength with which the adhesion takes place almost implies a large and powerful insect. When the viscid matter is set it will resist any force which the pedicle will bear, and this, although not more than one-twentieth of an inch across its narrowest part will support a weight of nearly three ounces. In *Catasetum luridum* the pollinia are so discharged when the filaments are artificially irritated that they attach themselves to the bottom of the concavity of the labellum; so that there is reason to believe they would be received on the back of any insect who was obtaining the contents of the labellum. By these insects it is inferred, and no doubt observation will confirm the inference, that the pollen masses are transferred to the stigmas of other plants. Before leaving *Catasetum*, we would observe, although somewhat digressing from our subject, that *C. tridentatum* is interesting on account of its polymorphism, and of the sexes being distributed among different flowers. The form to which the above specific name was originally assigned was the male flower. The female form was placed in a distinct genus as *Monachanthus viridis*; and a third form, which is of an hermaphrodite character, since it combines more or less of the female and male features, was considered to be a third genus, and was named *Myanthus barbatus*. Usually the three forms are borne on separate plants, but occasionally they are mingled together on the same plant. These three forms are remarkably different in structure and details, and to those who firmly believe that the amount of difference between two forms is a measure of the separation which should be accorded them in classificatory schemes, it may well seem, as Lindley remarked, that "such cases shake to the foundation all our ideas of the stability of genera and species," but to our mind it is only another illustration of the necessity of investigating the life history of a species, or of having a fairly probable knowledge of it inferentially before giving it its specific and generic name. We believe no biologist is in a position to say what amount of difference between two specimens is a good warranty for regarding them as specifically or generically distinct.

Another remarkable arrangement for securing the ejection of pollinia on an insect, and their transference in the proper position to the stigmatic surfaces, is afforded by *Mormodes ignea*. In this position the compressed column of the anther is situated above the pollinium, and the case containing it is connected with the prolonged tapering summit of the column by a short thread-like hinge. The pollinium and anther are so arched as to form a slightly bowed forward projection of the column. The labellum is turned up, and its shape may be compared in a rough way to a cocked hat on a cylindrical pedicle. The labellum is turned so far back as to rest upon the column, which is received in a depression which Darwin says represents the depression noticed in *Catasetum*. The surface of the labellum which is uppermost in *Mormodes* forms a disc, and the most convenient resting place for an insect. The column and the labellum are not opposite one another, but are twisted laterally to opposite sides. When the little hinge above mentioned is slightly touched a complicated series of motions is started, the result of which is to throw the pollinium perpendicularly upwards so as to fall with its viscid disc upon the crest of the labellum. No other part of the flower is sensitive, for provided the hinge be not affected it will withstand strong jolts and hard knocks without liberating its pollinium. But several parts may be touched, the intensity of the force varying with each, so as to affect the hinge, and to lead to the upthrow of the pollinium. In this species the precise *modus operandi* of the way in which the pollinium is liberated in nature is unknown, but it is not unlikely that Darwin is correct in believing it to be by insect agency. He puts his case in the following words:—"Now let us suppose an insect to alight on the crest of the labellum (and no other convenient place is afforded), and then to lean over in front of the column to gnaw or suck the bases of the petals swollen with sweet fluid. The weight and movements of the insect would press and move the labellum, together with the bent underlying summit of the column; and the latter pressing on the hinge in the angle would cause the ejection of the pollinium, which would infallibly strike the head of the insect and adhere to it. I tried, by placing my gloved finger on the summit of the labellum, with the tip just projecting beyond the margin, and then gently moving my finger; it was really beautiful to see how instantly the pollinium was projected upwards, and how accurately the whole viscid surface of the disc struck my finger and firmly adhered to it. Nevertheless, I doubt whether the weight and movement of an insect would suffice to thus act indirectly on the sensitive point; but look at the drawing [which we have not reproduced here], and see how probable it is that an insect leaning over would place its front legs over the edge of the labellum on the summit of the anther case, and would thus touch the sensitive point; the pollinium would then be ejected, and the viscid disc would certainly strike and adhere to the insect's head."

We could mention many other cases similar to those above recorded from the works of Darwin and Gray, as cited below, and other observers, but the reader cannot do better than consult the originals. The instances above given have evidenced more or less clearly that although the male and female elements are united in the same flower, yet they are not self-fertilizable, but are habitually crossed by the agency of insects. In a few species, however, such as *Ophrys apifera*, the bee-orchis, the parts are unquestionably specially adapted and arranged for self-fertilization. The pollinium, which has a doubly bent pedicle, is at first situated upright in a sort of protective hood formed by the anther. As the plant matures the pollinia retain their attachment by means of the rostellum, but fall forward, so that the pollen mass hangs loosely just in front of the stigmatic surface. As long as the air is still the pollen does not come in contact with the stigmatic surface, but with a gentle breeze the pollen mass begins to vibrate, and soon acquires sufficient swing to bring it against the stigma to which it adheres, and the fertilization is effected. Even in this species Darwin points out that there is also manifest contrivance for effecting cross fertilization by insect agency, and on the strength of this, and a few other circumstances, he thinks it safest to conclude, not that the species always self-fertilizes itself, but that occasionally, possibly at rare intervals, there is a cross between two individuals. Another form which is regarded by some botanists as a variety of *O. apifera*, viz., *O. arachnites*, has no adaptation for self-fertilization. This great functional difference, combined with slight differences in form and structure, seem to entitle *O. arachnites* to distinct specific rank. In America also there are two closely allied forms, one of which is self-fertilizable (*Platanthera hyperborea*), whereas the other is not (*P. dilatata*).

Before concluding this article we would just mention a monstrous blossom of *Cypripedium candidum* in which the parts are symmetrical, complete, regular, but dimerous, and in which there is a clear demonstration of two stamineal verticils, which Brown long ago insisted to be the ideal type of an orchidean flower. This case of regularity is very remarkable in an order, which is perhaps more conspicuous for irregularity of form than any other.

(Darwin, *On the various contrivances by which British and Foreign Orchids are fertilized by insects, and on the good effects of intercrossing*, 1862; Gray, *Am. Journ. of Sci.* 2nd series, vol. xxxiv. pp. 138—141, 259, 420—429; xxxvi. pp. 292—294; xlii. p. 195.)

OREODON. This is one of the many genera whose remains have been exhumed from the eocene strata of the Mauvaises Terres in Nebraska and near the eastern foot of the Rocky Mountains. A little farther north, on both sides of the Missouri, near where it is joined by its tributary, the Judith, is another district where eocene strata are developed, and which has also been called the Bad Lands. We mention the latter in order that the two districts may not be confused. It is distinguished as the Bad Lands of the Judith river, while the former are the Bad Lands of the White river. The Bad Lands of the White river form a most remarkable sight. All around for miles and miles stretches the uniform and monotonous prairie; at Mauvaises Terres there is a sudden valley depression of between one and two hundred feet below the prairie level. The valley itself is crowded with isolated pyramids and towers of rock, which simulate at a distance the ruins of some vast city. When the valley is crossed the traveller has to wind his labyrinthic way amidst these columnar patches of rock along narrow passages which remind him of the narrow byeways and streets of some quaint old town. The masses of rock tower above his head to a height varying from a few feet to between one hundred and two hundred feet. The top of the loftiest is nearly on a level with the surrounding prairie. The whole area appears to have been scooped out by some mighty river, with the exception of the crowd of rocky pillars. The pillars themselves are formed of a succession of freshwater strata, in which occur the *Oreodon* and other mammalian relics. The floor of the district is covered with the debris of the strata, and in it are embedded myriads of bones. The earliest remains belonging to the genus under notice were named *Merycoidodon;* other fragments subsequently found were assigned to two genera, *Oreodon* and *Cotylops*. The founder of all these, Dr. Leidy, is now convinced that all belong to the same genus, for which he retains the name *Oreodon*, not the earlier appellation *Merycoidodon*. Like so many of the old established mammalian genera it possesses characters linking together families and sub-orders, which appear to be separated by wide gaps as represented in the living fauna. It connects the living *Cervidæ* with that primitive form of ruminant, the *Anoplotherium*, and at the same time it has a more or less close resemblance to the *Camelidæ* and *Suidæ*. As may be expected from this statement, there are many points in its anatomical structure of great interest to the comparative anatomist, but we cannot go into details. The teeth form an almost continuous series, the gaps being of inconsiderable dimensions. The level of the teeth approaches in evenness that of *Anoplotherium*, the only material interruption of the plane being the projecting canines. The dentition appears to favour Milne-Edwards' opinion that the outermost pair of incisors in the *Moschidæ* are incisors, and not canines, as is maintained by Professor Owen, since *Oreodon* has eight incisors in the lower jaw, as also the canines. Dr. Leidy suggests the hypothesis that the functional canines may be the most anterior pre-molars modified into canines, a view which he observes is favoured by the absence "of the first of the normal number of molars, and also by the unusual position of the inferior canine tooth. Further, the latter has almost the exact form which would be produced by merely prolonging the crown of the first functional pre-molar. On the other hand, in *Palæotherium*, the lower and upper canines have the same relative position as in *Oreodon*, and yet the lower jaw has the normal number of pre-molars." The formula of the permanent dentition is as follows:—

Incisors, $\frac{3-3}{4-4}$; canines, $\frac{1-1}{1-1}$; pre-molars, $\frac{4-4}{3-3}$; true molars, $\frac{3-3}{3-3} = 44$.

This suggests another mode of looking at the question, but in the absence of an autopsy of the fossil remains, the conclusion must be regarded as simply hypothetical. In many of the earlier mammalian genera the full complement of the dental series consists of 44 teeth. Professor Owen looks upon such a set as typical, and believes that by identifying each tooth in such a set, one is able by a critical anatomical examination to determine what teeth are present and what teeth are absent in all placental mammals which have an incomplete set. So far as we are aware no form has a greater number, and moreover no form has a larger numerical development of any one kind of tooth than is contained in a typical set, which is formulated thus:—

Incisors, $\frac{3-3}{3\ \ 3}$; canines, $\frac{1-1}{1-1}$; pre-molars, $\frac{4-4}{4-4}$; true molars, $\frac{3-3}{3-3}=44$

Such a formula we have already stated is met with in many extinct genera, and it is also that presented by the common mole. As *Oreodon* possesses the full number of 44 teeth, there are none wanting, or in other words the typical set is present, although possibly more or less modified in form. On this hypothesis it would seem that what Leidy calls the fourth incisor in the lower jaw, although functionally incisors, are really typically the lower canines. His upper canines are so both typically and functionally; his lower canines are functional modifications of the first pre-molars, a view which harmonizes with their peculiar position, with their apparent absence, and with the hypothesis which he has himself suggested. Moreover, the presumed absence of these molars is not in harmony with there being 44 teeth. On this basis the dentition of *Oreodon* is a typical set, a few of the teeth having their functions modified. Dr. Leidy says of the dentition of *Oreodon* that it is remarkably distinct from that of any living or any known extinct genus, and that it indicates the combined habits of ruminating and suilline animals, or, in other words, it appears to characterise a ruminating hog.

(Leidy, *The Ancient Fauna of Nebraska.*)

ORGANIC REMAINS. [E. C. vol. iv. cols. 115—121; PALÆONTOLOGY, E. C. S.]

OXYGEN. This substance is usually considered to belong especially to the domain of chemistry, and hence most descriptions of it are mainly based upon facts, as seen from a chemical point of view; its examination from a purely natural history point of view is quite as important and interesting. In this account, however, attention will not be restricted either to the one or to the other, the object being to arrive at broad general ideas.

The almost incredible abundance of oxygen in nature is alone a sufficient justification for its treatment in this division of E. C. The commonest compounds are largely composed of it. Thus it forms eighty-nine parts by weight of water, about fifty per cent. of silica, alumina, and limestones; and these last constitute by far the greater proportion of the aggregate weight of all the rocks and minerals known. The organic kingdom also contains vast quantities of oxygen stored up in fluids, tissues, and cells, but in these carbon is the predominant and characteristic ingredient. Disregarding plants and animals, it may safely be said that one-half of the weight of the outermost layer of the earth, as far down as man has been able to get, is due to oxygen. The whole of this enormous mass of oxygen is chemically combined with other substances which greatly modify its properties. Free or uncombined oxygen is only known in the gaseous state, and as such it forms twenty-five per cent. by weight of the atmosphere. It would be possible to state roughly what the total weight of the oxygen is, but the figures would be so enormous as to elude the grasp of the mind. For instance, to take the oxygen in the air only, which is manifestly a very small proportion of the whole, the estimated weight is about 1200 million of million of tons. Its properties as a gas will be found under OXYGEN, Arts and Science Division, but the details there given do not bring out its relations to other elements so clearly as might be desired, so that we propose to restate its properties in another way in the present article.

The weight of a body is the attractive force between it and the earth, and this force is always proportional to the quantity of matter, so long as the accompanying conditions are unaltered. This weight is usually expressed in figures referring to some arbitrary standard, such as a pound, a kilogramme, &c., the standard being an accurately defined mass of some substance, generally water, at a given temperature, and under a given pressure. The unit of weight here adopted is 1 gramme (15·44 grains) of hydrogen, having a temperature of 0° C. (32° F.), and subjected to a pressure equivalent to that of 760 millimetres (29·91 inches) of mercury. This is also adopted as the unit of mass or quantity of matter, and as the unit of volume. When a similar bulk of oxygen is weighed under the same conditions it counterbalances 16 grammes (247 grains); so that if hydrogen be 1, the specific gravity or relative weight of oxygen is 16, or in other words there is 16 times more matter in oxygen than in hydrogen when similar volumes are exposed to identical conditions. These conditions are, as we have indicated, definite degrees of gravity, pressure, and temperature, combined with perfect isolation. The gravity depends upon the mass of the earth and the distance between the centres of gravity of the earth and of the object weighed, together with the rotatory velocity of the globe. The mass or weight of the earth is believed to be constant; while the variation in the distance between the two centres, as also in the velocity of the surface of the earth with latitude, can have a very unimportant influence on the relative weights of equal volumes of the different elements or compounds. It will therefore facilitate calculations, and yet not interfere with the accuracy of the results, if the force of gravity be considered constant; more especially when it is borne in mind that the figures we shall employ cannot claim to be rigorously accurate, but only close approximations. The remaining conditions are temperature and pressure, the slightest variation of either of which greatly influence the relative volumes of different gases. What then, it may be asked, is the relation between pressure and volume, or temperature and volume? meaning by the word temperature the intensity of heat and not its quantity.

Oxygen is known to expand by $\frac{1}{273}$ of its bulk when heated from 0° to 1° C. (32° to 33° 8 F.) under a constant pressure of 760 mm. (29·9 inches) of mercury at that temperature, which pressure is 1·033 kilogramme on the square centimetre, or about 14·4 lbs. on the square inch. A unit volume of oxygen weighs 16 grammes (247 grains), and consequently a kilogramme will occupy the volume of 62·5 mass units, or 699·37 litres (1239·6 pints). When the temperature of this volume, which we shall call in round numbers 700 litres (1240 pints), is raised from 0° to 1° C. (32° to 33°·8 F.), it is also expanded to 700 litres × $\frac{274}{273}$ litre, or 702·56 litres (1244·5 pints). During this expansion force is exerted in pushing against the pressure, which force is equivalent to raising 1·0333 kilogrammes to a height of 25·6 metres (1007 inches) for every square centimetre of area, or 1 kilogramme to a height of 26·5 metres. The work done in expanding therefore corresponds to a moving force of 26·5 kilogrammetres (191·8 lbs.), which force applied as pressure would suffice to reduce the gas to its original bulk if the temperature be kept unaltered. Heat, however, is expended in raising the temperature as well as increasing the bulk. The ratio between the heat required to raise the temperature from 0° to 1° C. when the volume is constant is to that required when the pressure is constant as 1 is to 1·1414; and as the volume is kept constant by means of some external force, such as pressure, the quantity of heat represented by ·414 is equivalent to such pressure. This pressure has been already ascertained to be equivalent to 26·5 kilogrammetres, and therefore the ·414 of heat is also equivalent to this force, while the quantity represented by 1 is equivalent to 64 kilogrammetres; and the whole quantity of heat required to raise the temperature of one kilogramme of oxygen from 0° to 1° C. under constant pressure, corresponds to 26·5 + 64 = 90·5 kilogrammetres (6510 foot-pounds) of motion.

Heat and pressure, then, are two antagonistic forces, which are always striving to produce opposite effects. In the case of gases heat is an expanding force, and pressure a condensing one; the one acts in the opposite direction to the other, in precisely the same way as the forces exercised by the two weights in a balance act in two directly opposite directions. The common balance enables us to measure the relative forces exercised by two weights, and the mass of gas enables us to measure the relative forces of heat and pressure. The ratio between these in oxygen is known, and it is also known to be the same in hydrogen as well as all other similarly perfect gases. As the properties of hydrogen are here adopted in many cases as the standard units, we may here define what is meant by a unit of heat and a unit of pressure. The unit of heat is the quantity required to raise one gramme of hydrogen of unit volume from 0° to 1° C. when under constant pressure; and the unit of pressure is the force required to reduce the volume of one gramme of hydrogen at 1° C. when under a pressure of 760 mm. of mercury to the unit volume, the temperature still remaining 1° C. The heat unit corresponds to 1·028 kilogrammetres (7·37 ft. lbs.), and the pressure unit to ·424 kilogrammetre (3·05 ft. lbs.) So that whatever a heat unit does is equivalent to 3·3 times what is effected by a pressure unit; and a pressure unit will counteract the work done by ·296 of a heat unit.

Recurring again to oxygen, it will be noticed that when a kilogramme is heated from 0° to 1° under constant pressure a quantity of heat equivalent to 90·5 kilogrammetres is absorbed, of which the proportion represented by 64 kilogrammetres is spent in raising the temperature, and that represented by 26·5 kilogrammetres in lifting the pressure; consequently, when one gramme is heated from 0° to 1° the temperature will be represented by ·064 kilogrammetre, and the pressure by ·0265 kilogrammetre. These numbers are just $\frac{1}{16}$ of the corresponding numbers for hydrogen. Thus, ·064 × 16 = 1·024 kilogrammetres; and ·0265 × 16 = ·424 kilogrammetre.

Having thus obtained a tolerably accurate idea of what heat and pressure do on a small scale, it may be asked what would be the effect when large quantities of heat or pressure are applied to the unit of volume. For instance, what force is required to reduce oxygen to the density of water? In considering this question we will, for the present, disregard the results obtained in the experiments made to condense gases by pressure, and will suppose that the rate of contraction is uniform for equal additions of pressure, and that pressure is the only condensing or contracting force brought into operation. One unit of pressure, ·424 kilogrammetres (30·5 ft. lbs.) reduces the bulk of 16 grammes of oxygen of unit volume by $\frac{1}{273}$, and 273 such units = 115·6 kilogrammetres (835·55 ft. lbs.) will halve its bulk, and consequently increase the density from 16 to 32, provided the temperature be kept constant at 0°. A further pressure of 115·6 kilogrammes will increase the density from 32 to 48; or in other words, increase the weight of a unit volume of oxygen from 32 grammes to 48 grammes. For every addition, then, of 273 pressure units the density is increased by 16. The same applies whether the original bulk be one gramme or 16 grammes; and it will facilitate calculation if one gramme be taken as the starting point. The force required to increase its density from 16 to 32 is $\frac{1}{16}$ of 115·6 kilogrammetres, or 7·16 kilogrammetres. The density of ordinary water at 100° C. (212° F.) is 10,179 as compared with hydrogen = 1, and the force required to condense oxygen is 7·16 kilogrammetres × $\frac{10,179-16}{16} = \frac{10163}{16} = 4512$ kilogrammetres. The force required for 16 grammes would be $4512 \times 16 = 72,122$ kilogrammetres. Water is usually called H_2O, but this is a chemical compound, and not a mechanical mixture; hence the force required to condense two vols. of hydrogen and one vol. of oxygen so combined, is not the same as if they were simply mixed. If they were simply mixed, the specific gravity of one volume would be 6, and the force required would be $115·6 \times \frac{10,179-6}{6} = 195,942$ kilogrammetres. When H_2 and O combine they form a compound, whose density under the standard conditions is 9; and the force required to convert this to the density of water at 0° is $\frac{10,170}{9} \times 115·6 = 130,643$ kilogrammetres. The force for one gramme would be 14,515 kilogrammetres = 34,310 gramme degree units. According to Favre and Silberman's experiments, which seem to be the most trustworthy yet made, the heat evolved from each gramme of water when combination takes place is 34,462 gramme-degree heat units. Our calculated results come very near the experimental results. The precise calculated figures depend partly upon the degree to which decimals are carried out, and partly upon the temperature at which it is assumed the combination occurs.

As the density of the water is retained at 0° and 760 mm. it is clear that the density is due not to any increase in pressure, but to an increase in the force which keeps the particles chemically united; and it would require a similar force applied in some way or other to disunite the two elements. In comparing the above results it is important to bear in mind that the heat is that given out by 1 gramme of steam. If, therefore, 1 gramme represents the atomic weight of hydrogen, then the heat evolved by the molecular weight of H_2O is 34,310 gramme-degree heat units $\times 18 = 617,580$ heat units. We attach great importance to the strict definition of chemical symbols. In most chemical books H_2O means water generally, whatever its state of condensation, and whatever its bulk. We suggest that there would be an advantage in applying the symbol so as to indicate, where necessary, a definite quantity of matter or of force. Thus H_2O might stand for water generally as at present; but where greater precision is requisite, as in cases where the quantity and condition of the matter are elements in chemical combination, we should indicate such facts by modifications of the symbol. Thus one method which suggests itself as practicable may be exemplified by H_2O (1 : 9); H_2O (10 : 10,179), the first of which stands for 1 gramme of the compound in its most highly rarified state; and the latter 10 grammes of boiling water; both being under the standard conditions as regards temperature and pressure. The plan may seem a confusing one, but it will probably be found to facilitate the working out of chemical problems when the consideration of heat or any other of the modes of motion or forces enters into the question. Again O would stand for oxygen generally as at present; but if we wished to indicate the element when subjected to no other forces than is represented by a pressure of 760 mm. and a heat of 0° C., we should designate it as O (0 : 16); while 1 gramme would be represented by O (1 : 16); and the atom as now usually accepted in text books by O (16 : 16).

When oxygen and other gases are actually subjected to pressure they do not contract according to Boyle and Marriotte's law, so that, strictly speaking, the density is not directly as the pressure; it is always somewhat greater. This anomaly appears to arise from a second force, viz., cohesion, or idio-attraction, being brought into play. The density is consequently an effect produced by pressure and cohesion, but as no one seems to have ascertained what share each force separately has in producing the final result, we have assumed in the foregoing calculations that pressure is the only force, and that cohesion acts in the same way as pressure alone would do. That this assumption is warrantable seems to be shown by the calculated results being almost identical with those obtained by experiment.

If this article were intended to be an exhaustive or even a full systematic account of oxygen, we should next proceed to indicate its relations to the other physical forces, such as light, electricity, magnetism, &c.; but as our aim is not so high, we pass on to the general chemical properties of this element. Oxygen combines with almost every element, and the different oxygen compounds possess a great variety of characters. If the inquiry were properly carried out care should be taken to compare the chemical activity of oxygen under different yet comparable conditions; according as it is dry or moist, cold or hot, in small quantities or in large quantities, when acting on small or large surfaces, &c. The combinations of oxygen with the lighter elements are remarkable for the immense quantity of heat which they evolve, and generally speaking the quantity is less in proportion as the combining element is heavier. Thus H_2O (1 : 10,179) evolves a heat of combination of 34,000 units; while according to Andrews 1 gramme of oxide of copper only gives out 603 heat units. Many other illustrations might be given. The quantity of heat given out is to a certain extent a measure of the force of cohesion, and consequently of the stability of the body. Those which give out most heat are the most stable, and those which give out least, least so. Conversely it is found that less force or heat is required to decompose or separate the elements of the unstable compounds than the stable ones. Indeed the quantity of heat required for decomposition is a direct measurement of the strength of the affinity. Oxygen has greater affinity for the light elements, such as sodium, potassium, &c., than for the heavier ones, such as platinum. Oxygen and the lighter metals combine at ordinary temperatures, but it requires more or less heat to effect the combination of the oxygen with the heavier metals. Hence it is that the lighter metals are so much more rare than the heavier ones in the native state. We have used the word affinity in this paragraph in the sense ordinarily adopted by chemists, viz., the attractive force which causes elements to unite into chemical compounds, and in so doing we have made a statement at variance with the general tenour of our remarks, since we have implied that an increase of heat is capable of increasing the intensity of an attractive force. In order to get rid of this ambiguity we should be inclined to measure the strength of the combination, not by the energy displayed under the present ordinary conditions under which such combinations are effected, but by considering how far that energy is modified by the co-operation of other forces. Thus to explain what we mean we may suppose there to be two kinds of cohesion, one of which we will distinguish as physical cohesion, and the other as chemical cohesion. The former acts on particles of a similar nature, and the latter on particles of a dissimilar nature. The two kinds of cohesion have different relative strengths according to circumstances; in ordinary parlance the excess of the chemical cohesion over the physical cohesion is considered as the indication of the strength of the chemical affinity; but we think it would lead to clearer ideas if the intensity of the chemical cohesion, when acting independently of all other forces, be taken as the indication of strength. We may then conceive that the application of heat may increase the tendency to combination either by the relative weakening of the physical cohesion, or indirectly by increasing the pressure, as when bodies are burnt in a confined space full of gas. We believe that there can be no increase in the force of either kind of cohesion by the action of increase of heat only, whether the increase be in quantity or in intensity.

One of the most marked features of oxygen is its combustibility; but it must not be supposed that it is the only combustible element; it should rather be looked upon as generally the most combustible. Combustion is the name given to the heat and light effects produced whenever there is an intensity of chemical action, which action is always attended by a corresponding intensity of contracting force. No other element equals oxygen in this respect; still there are many cases in which strong heat and light are given out where other elements, besides oxygen, combine together. As the quantity of light and heat evolved is a measure of the force required to form the product, it follows that, generally speaking, more force is expended in producing oxides than any other simple combinations between two elements, such as sulphides, and therefore it would require more heat to decompose oxides than sulphides, &c. We have already stated that the earth's crust is largely composed of oxides and oxygen compounds, and that oxygen compounds are also found in the organic world. The most marked distinction between these two groups of compounds is that, generally speaking, minerals are incombustible, and not easily decomposed by heat; while organic oxygen compounds are for the most part combustible, and readily decomposed by heat. The more common oxygen salts amongst minerals, such as silica and the silicates, the soda, potash, and lime salts, are remarkable for their stability; while the oxy-hydrocarbons of animals and plants are as remarkable for their instability. In other words, it requires more mechanical force or its representatives to change minerals, but a slight amount only to change organic compounds. This leads to the inference that the force required to combine organic compounds is far less than that required to combine inorganic compounds; and therefore that the molecular constitution of inorganic compounds must be more complicated than that of organic compounds, since the latter are by far the lighter of the two groups. The molecules themselves may be complex in organic compounds, but the number of molecules in a given space, say the unit volume here adopted, is by far the greatest in the minerals. For instance, one of the most complex of organic substances is stearin, the formula for which is $C_{57}H_{110}O_6=173$ atoms. Clay as ordinarily written is $(Si\,O_2)_3\ Al_2O_3$ or $Si_3\,Al_2\,O_9$. If clay were so composed, the volume corresponding to that adopted for 1 unit of hydrogen, which is 11·19 litres, should have a density of

$$\begin{array}{lcrcl}
\text{Silicon} & = & 3 \times 28 & = & 64 \\
\text{Aluminium} & = & 27{\cdot}5 \times 2 & = & 55 \\
\text{Oxygen} & = & 16 \times 9 & = & 144 \\
\hline
 & & & & 263
\end{array}$$

supposing it to be a one-volume compound, and 131 supposing it to be a two-volume compound. The specific gravity of ordinary clays is about 2·5 on the water scale, or 27,495 on the hydrogen scale. The formula, corresponding to that of stearin, is $Si_3Al_2O_9 \times \frac{27{\cdot}495}{131} = Si_{627}Al_{418}O_{1881} = 2926$ atoms. This shows also how much more highly oxidized the silicate is than the stearin. If we wish to compare their relative combustibilities we must calculate their relative degrees of saturation by oxygen. When silicon is thoroughly burned it becomes SiO_2; aluminium becomes Al_2O_3; carbon, CO_2; and hydrogen, H_2O. The Si_3O_6 corresponds to $Si_{627}O_{1254}$; Al_2O_3 corresponds to $Al_{418}O_{627}$; and $Si_3Al_2O_9$ corresponds to $Si_{627}O_{1254} + Al_{418}O_{627} = Si_{627}Al_{418}O_{1881}$. So that the silicon and aluminium are thoroughly oxidized in the clay, and not being capable of further oxidation under ordinary circumstances are incombustible. The CO_2 would correspond to $C_{57}O_{114}$; H_2O to $H_{110}O_{55}$; and the two together to $C_{57}O_{110}O_{169}$. Hence stearin is hardly oxidized at all, is capable of taking up a great deal more oxygen, and is accordingly a combustible body. In this way it would be possible to draw up a table, showing the combustibility or incombustibility of bodies so far as oxygen is concerned. As a rule, minerals are thoroughly oxidized bodies, and minerals constitute the food of plants. The most important items are carbonic oxide or thoroughly oxidized carbon, and water, or thoroughly oxidized hydrogen; and the materials of plants are almost entirely composed of these two substances deprived of the great bulk of their oxygen. Now we know that an immense force was required to bring oxygen in combination with these elements; and the same force is necessarily required to separate it from them. This force is actually exerted by plants, and the force is almost entirely derived by them from the sun's light. Plants, then, form an ever active machinery for the manufacture of more or less deoxidized compounds and of free oxygen.

Animals are distinguished from plants and minerals by their constant activity and marvellous powers of motion. Neither motion nor force is developed to any great extent in mature plants; but a mature animal is a magazine of highly concentrated force always ready for application. This general difference is intimately connected with the fact that the food of plants is thoroughly saturated with oxygen, while the products formed from that food are not so saturated; so that there must necessarily be a deoxidation. The life of animals primarily depends upon vegetable matter, and this is transformed into muscular tissues and those compounds from which the muscular force is derived; all of which are imperfectly oxidized. The word primarily is used above to mean that carnivorous animals would be unable to exist were there no plant eaters, not to imply the exclusion of a first Great Cause. Unfortunately, little is known as to the precise chemical composition of the muscular and other animal tissues, so that no rigorous comparison can be made between their oxidation and the work performed. The main phenomena connected with the performance of work are, however, sufficiently well known. The majority of the tissues are complex, more or less imperfectly oxidized, and therefore unstable compounds; while the waste products are for the most part simple stable compounds, almost completely saturated with oxygen, such as water, carbonic acid, and ammonia, or simple combinations of them.

So far we have confined ourselves to the present relations of oxygen; but there is another branch of the subject which is full of interest, but which has as yet received very little attention. The branch alluded to comprises the relations of oxygen to other substances in time past, or, to use a word generally applied in another way, its palæontology. This application of the phrase may be new to many, but the study of the relations of oxygen and other elements occurring in nature belongs to the geologist quite as much as do the relations of limestones, clays, sandstones, &c. The materials available for such an account are somewhat difficult to collect, but one idea that could be developed is that the earth's crust is most oxidated in the outer layer, and less so in the inner layer known; and that meteoric stones contain still less oxygen, and meteoric irons almost none. Hence it might be conjectured that the innermost layer of the solid part of the earth resembles aerolites in its nature, if it be not, as some suppose, the source of the aerolites themselves. It would be desirable to know what relation the above distribution of oxygen has with its chemical affinities for the twelve elements most frequently combined with it, viz., silicon, aluminium, magnesium, calcium, potassium, iron, carbon, hydrogen, chlorine, and nitrogen. The result of such an enquiry would probably indicate that, generally speaking, the oxides formed at the highest temperature are relatively most abundant in the innermost layer, and those formed at the lower temperature most abundant near the surface. Doubtless many apparent anomalies would be detected, but most of these would be explained by a consideration of the sifting action of water, which subject, however, more properly belongs to lithology. The enquiry would probably bring out the conditions and period when the oxides were first formed on the globe, indicate their gradual increase so as to adapt the earth to be the dwelling-place of organisms, and demonstrate what an enormous quantity of oxygen has been converted from the gaseous to the solid stable form.

Before concluding this article we would just allude to the allotropic form of oxygen, viz., ozone, the varying proportions of which in the atmosphere is an important element in a climate, since it is closely connected with the health of animals, and especially of man in crowded districts. In its properties it resembles oxygen, except that they are intensified. Thus ozone will accomplish at ordinary temperatures what oxygen will do only at a much higher temperature; and dry ozone will do what moist oxygen will effect, the other circumstances remaining unaltered. The condensed oxygen formed by means of platinum black approaches ozone in the intensity of its properties; and we believe that oxygen dissolved in water is more active, not because it is more moist, but because it is more condensed. A unit volume of ozone under standard conditions contains 24 grammes; but this increase of density appears to be due to some internal molecular attracting force.

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PALÆONTOLOGY [ORGANIC REMAINS, E. C. vol. iv. cols. 115—121]. The archives of palæontology are contained in the great stone book, the special study of which belongs to the geologist. The leaves are the strata or bands of stony material, and the letters are the organic remains which are actually embedded therein, or have left their impression thereon. The experience of the student teaches him that he never sees a whole leaf fairly spread out, but only bits of it here and there scattered at distant intervals over the capacious earth. Portions of it are overwhelmed in the waters, and beyond the reach of his ken; other portions have been carved by the graving tools of nature, and the chips have been carried off to form portions of some newer leaf; and other portions are wrinkled and crumpled so as to reverse their original position with reference to the earlier leaves. Sometimes the leaf has been so damaged or hidden that no trace of it has been discovered, and the gap is indicated by signs readily recognizable by the stone-book-worm. Occasionally several, or even many leaves, have been torn out so as to make a very conspicuous gap. Gaps of variable extent, both vertically and horizontally, are caused in another way, connected with the mode of manufacturing the book. The leaves were never formed over the whole extent of the book, but only over the spaces between the older crumpled, wrinkled, disturbed, and excavated leaves, which were below a definite level. If the leaves are in a defective and dilapidated condition, so are the letters. In their case whole words and sentences are wanting, and even whole pages; the letters are battered, squeezed, broken into fragments, and chemically altered. The result of all this is that the palæontologist has great difficulty in reading the book, and in making out the general tenor of the text; sometimes he is only able to make a blind guess as to what a letter or a word really is; sometimes he mistakes one word for another, and hence misinterprets the text; and when whole pages are missing it is no wonder that he is frequently quite at a loss how to supply the omission. This text has been written by the Great Creator, and is being continued at the present time. If we could obtain a complete copy, and could accurately decipher the language as well as understand its many technicalities, we should learn what are the laws of life, and what have been the conditions under which that life has flourished in each succeeding age. This same book is impressed with another set of characters belonging to a different language, and like the former set have been so inscribed as to constitute a continuous text. This text is also imperfect, and if it were read accurately would inform us as to the history of the physical geography of the globe from the earliest period to the present time. In order to get a clear understanding of the text of life, the text of physical geography should be simultaneously consulted. The one is the complement of the other. In reading the following general abstracts of these texts the reader must never forget how difficult is their interpretation, how difficult it is to avoid mistakes, and how incomplete is the original record. The letters and words are so numerous; corrections, re-corrections, and new readings are being propounded by so many readers; the text is so extensive; and the multitude of emendata are scattered over so many scientific journals and publications that it is exceedingly difficult for any one person to ascertain what is the present state of our knowledge respecting the text. On carefully examining both texts, the first impression conveyed to most minds is that although the language used in each case is the same from the first page to the last finished off, yet that, as in the languages of men, little changes are constantly occurring in the shapes, sizes, and mode of forming the letters, in the technical meaning of the words, and in the kind of words employed, some becoming obsolete, and new ones being constantly introduced. Hence the farther back we go in the volume the more strange does the language seem to us, and the more difficult is it to interpret, even when deciphered. In both cases also it is observable that while at first the letters and words were few and in general use all over the globe, yet as time elapsed their number and variety increased, and the globe became more and more parcelled out into districts in which distinct dialects prevailed. There was change, and this change indicates the action of laws regulating a progressive and methodical evolution. So it has been with the languages of men; at first all spoke one tongue; as time went on changes occurred, and now no one individual is able to master the hundreds of languages and dialects which exist. The changes seem at first sight mere matters of chance, but philologists who have traced out the evolution of words are convinced that it is all subject to law, and that the Bosjesman, the New Zealander, the Australian, the Chippeway Indian, the Mongol, and the Englishman, who may now jabber in one another's faces without any two of them having the slightest inkling of any community of understanding, may have been derived from a people whose tongue was universally understood. Such seems also to have been the law of progress of life; but, as will be again mentioned, there is a difference of opinion whether there has been a continuous evolution of words out of each other along various lines, or whether the types have been made by distinct acts of creation, and subsequently arranged in their proper places so as to form the continuous text.

There has been change—a proposition which no one will dispute; and that change has occupied time, a proposition which is also unassailable. What the rate of change has been, and what the lapse of time, are points upon which no common agreement can be come to. As regards the absolute age of the globe, or of life, many attempts have been made to estimate it, but as the premises started from are unsafe, so the conclusions arrived at are untrustworthy; nevertheless these attempts teach some things; amongst others that the duration of life has been exceedingly great. Some of the methods employed also promise to aid us in determining whether we have the earliest portion of the palæontological record, and if not, whether the first page belongs to a near or distant anterior age. One way of arriving at the absolute duration of life is to assume that the globe was once a heated sphere, and that its temperature has been continually cooling at a regular ratio. Life could only begin at a certain temperature and under certain conditions. The temperature to be assumed is uncertain, but Professor Haughton selects that of 122° F. (50° C.), because albumen coagulates at that temperature. Helmholtz calculates from some of Bischof's experiments on the rate of cooling of basalt that the earth would require 350,000,000 years to cool from 2000° C. to 100° C. Then would be the first opportunity for the formation of seas by the condensation of steam. At the same rate of cooling, 1,018,000,000 years would pass before the temperature was reduced to 50° C. (122° F.), or that at which uncoagulated albumen could exist, according to Professor Haughton; while a further lapse of 1,280,000,000 years would bring the temperature down to 77° F. (25° C.). Below this limit the temperature of climates is influenced by the distribution of land and water, currents of air, &c.; but supposing the above calculation to be correct, it may safely be estimated that another 1,000,000,000 of years would be required for the temperature to be reduced to its present amount. The total figure is 3,648,000,000 of years; while the first possible commencement of life is about 2,300,000,000 of years ago; and before this aqueous, strata may have been accumulating for 1,000,000,000 of years. One of the assumed premises upon which these calculations are founded is that the solar temperature has been constant, but there are good reasons, say some, for conjecturing that the sun itself formerly had a higher temperature than now, and has been gradually cooling. If so, the above figures are under-estimates. Professor Thomson, however, is far from being so liberal in his allowance as to the duration of geological, or rather of solar, time. He says that probably the "sun has not illuminated the earth for 100,000,000 years, and almost certain that he has not done so for 500,000,000 years. As for the future, we may say with equal certainty that inhabitants of the earth cannot continue to enjoy the light and heat essential to their life for many million years longer, unless new sources, now unknown to us, are prepared in the great storehouse of creation." All our ideas as to the central heat of the earth, and of the rate of cooling, are hypothetical. Let us next take as a basis another fact, which certainly appears to us a tolerably sound premise. It is that the length of the year has remained appreciably the same ever since the time of Hipparchus and Ptolemy; and no error of observation can be admitted so large as would imply that the day had shortened by the $\frac{1}{100}$th part of a second. A contraction of the earth adequate to produce this shortening would amount to the $\frac{1}{170}$th part of one centigrade degree. If we suppose that the cooling has been on the average the $\frac{1}{100}$th part of a degree in every 2,000 years for the last portion of geological time, it would require us to go back 300,000,000 years to reach the period when the earth's temperature was 15° C. higher than now. This, of course, refers to the heat derived from the earth itself, and not to the increase of heat which places may have acquired by the influence of air and water currents, which transfer the heat of equatorial regions to localities between them and the poles. Such climatic changes may proceed at a much greater rate than secular terrestrial cooling. The utmost we learn from these hypothetical views is that life and terrestrial physics have been in operation for a very long time; and the principal lesson to be drawn is to allow as little time as possible to all natural events consistent with probability. The tendency of geologists is to assume that the time is practically unlimited, and to make no scruple about allowing any amount of time that their views may seem to require.

Since there is no sure method of gauging geological time, one is compelled to chronologise palæontological events in successional periods. The tests of relative age are of three kinds. By the first kind we know that one rock is younger than a second when the former contains fragments of the latter, and when the one overlies the second, without there being any proof of inversion. The second kind is based upon the mineralogical composition, and is safely applied for local areas and portions of strata, rather than in a general way. The third kind, which is second in importance to the superposition of strata, is by means of characteristic fossils, a test which often enables us to determine the relative ages of rocks when so tumbled about that the superposition test is inapplicable. In what beds, then, it may be asked, are the earliest organic remains discernible? At present the oldest fossils known were obtained from a limestone of the Laurentian system, which is situated nearly 17,000 feet above what is supposed to be the lowest stratified deposit as well as the oldest rock of any kind yet discovered. At about 5000 feet above the base of the system, so far as discovered, is a thick band of limestone, and as there are some reasons for believing such limestone has been formed by organic agency, it would be hazardous to assert that any rock seen by the geologist was formed at a period when as yet the stream of life had not commenced. If marine limestones, generally, have had such origin, Laurentian life was not scanty, judging from the immense thickness of the limestones of that age [LIMESTONES, E. C. S.]. And if we adopt the hypothesis of the cooling globe, the condensation of water, and the long prevalence of seas too hot to sustain life, we would infer that there is or has been a great thickness of truly azoic strata below the lowest Laurentian. Indeed the Laurentian strata themselves afford evidence that they have been derived from older rocks [LAURENTIAN FORMATION, E. C. S.]. These oldest fossils belong to the lowest class of animals, but as the evidence of the nature of the Laurentian fauna is very scanty, it would be premature to fasten upon these as the first signs of life, however convenient their nature is to the hypothesis of the progression of life from the rhizopods to more highly organised groups of beings. It is very possible that even mollusca may have then been living, since these older Laurentian strata contain particles which are strikingly similar to the shelly fragments in Silurian limestones. These earliest relics, it will be observed, are animals, and as the relation between animals and plants at the present time is such that we cannot conceive of the existence of the former without the latter, it is inferred that plants were formed as soon as, and in all probability before, the animals. If plants were the earliest organisms, they must have preceded the *Eozoon*. Passing upwards through a vast pile of barren strata having an aggregate thickness of some 30,000 feet, the next oldest remains probably belong to the lowest of the Cambrian strata of Europe, viz., the *Eophyton* sandstone of Lugnås in Sweden. In this sandstone have been found the earliest known traces of plants, of the organic nature of which there is good presumptive evidence. There are probably earlier traces of plants, such as, for instance, the graphite and other deposits of carbon or of carbonaceous matter in the oldest strata, even as low down as the older Laurentians, but the plant origin of such deposits is open to objection. Associated with the *Eophyton Linnæana* and *Eophyton Torelli*, which seem to be vascular cryptogams, or possibly phanerogams, have been found *Rusophycus dispar*, a nondescript organism; *Arenicolites spiralis*, the name given to a kind of worm burrow; and a few species of brachiopods, one of which has been provisionally named *Lingula* (?) *monilifera*. In strata of a somewhat later date, viz., the lower Cambrians of Great Britain, have been found several doubtful forms, supposed to be seaweeds, a few annelids, and a trilobite crustacean. In all these very early deposits the fossils are so few, and so widely separated vertically and horizontally by barren strata, that no inference can be relied on that is based on negative evidence, unless supported by sound collateral testimony. Thus, one of Bronn's laws, which are quoted farther on, is that plants and animals appeared simultaneously; and in proof of the truth of his statement he cites the co-existence of plants and animals in the oldest group of beings known to him in 1856, and which belong to what we shall presently mention as the upper Cambrian fauna and flora, but which is termed by him the primordial fauna and flora, or those which were first created. The species which we have already mentioned are not only pre-primordial, but some are of immensely greater age. The oldest part of the record is so manifestly incomplete that it would be hazardous to lay it down as a law that animals were created before plants, because *Eozoon* is Laurentian and *Eophyton* is Cambrian; it would be equally hazardous to state in an authoritative way that the first plants were created simultaneously with animals, even if a plant were to be discovered associated with *Eozoon*, for what proof is there that these were the earliest organisms, or even the highest in their day? As we have already stated, there are indications, which may prove to be false ones, that there were Laurentian molluscs, and if so there is high probability of a long antecedent stream of life. Again, Bronn lays down the law of the progressive development of plants as involving the succession to be from the *Cellulares* to the vascular cryptogams, and so on to more specialised groups; and in support thereof cites the fact that, when he wrote, the earliest known plants, viz., all those of Silurian and early Devonian age, could be assigned to no higher group than *Cellulares*. Now, however, we know of a much older vascular cryptogam; and this points to the probability that the true primordial flora dates from a period earlier still. We must wait a long while before we can determine by actual evidence what the actual order of succession of the earliest organisms was; and we must attach more importance than is usual to the value which ought to be given to the evidence, whether positive or negative. The simple circumstance that we are not aware of the existence of the remains of plants or of fishes in the Laurentian strata is in itself of no value; we must be in a position to give valid reasons why they have not been found, and why their existence is improbable; when these reasons are forthcoming, the negative evidence becomes valuable; indeed, in many cases this kind of negative evidence is equal in importance to the positive.

On ascending in the geological column of strata, we come next to the upper Cambrians, which embrace the *Lingula* flags of Great Britain, and the beds of which contain Barrande's primordial fauna. The fossils become more plentiful and varied. As yet, nothing but a few fucoids have been found to represent the plants, but it is difficult to admit that fucoids can have been the only plants of the period. In Great Britain not a single specimen had been discovered until a few months ago, when a specimen of a vascular plant was found in the lower Arenig beds (which we should place at the summit of the Cambrian group). This plant has been named *Eophyton* (?) *explanatum*.

The general character of the fauna of the upper Cambrian strata of Great Britain, may be gathered from the list given under CAMBRIAN GROUP, E. C. S., cols. 192, 193. From it we gather that all the four invertebrate sub-kingdoms were represented, a fact of great importance in many respects. If, as seems very probable, the stream of life commenced in unity, and flowed on in an ascensive order to heterogeneity, the co-existence of the four invertebrate sub-kingdoms at the time, would of itself imply, that the source is traceable much farther back in time. The same thing is indicated by the circumstance that the predominant groups belong not to the lowest sub-kingdoms, but to the highest; thus, the trilobites amongst *Crustacea*, and the brachiopods amongst *Mollusca*, far out number all other classes. In Great Britain, nearly three-fourths of the species are trilobites; nearly one-fifth are brachiopods; and the remainder belong to other classes. The number of species is not a true gauge of the importance of a class; a better test is the number of individuals; and a still better one, the mass which the individuals would form if aggregated together. From this last point of view, the brachiopods would appear to have the best claim to be regarded as the predominant group. Bronn has some tables and remarks on the geographical distribution of the oldest faunas, which refers as much to the Silurian as to the Cambrian age. He dwells more particularly on the uniformity of the faunas wherever the Silurian strata have been explored. There are, no doubt, specific differences between one district and another, but for the most part, the same generas and families occur everywhere; some of the species range over such vast areas that he asks what genera or species at the present day have such ranges. Although, perhaps, inclined to coincide with Bronn's view in its general aspects, we suspect that he has overrated the degree of community of genera in the Silurian era, and underrated the degree to which modern genera range at the present day. We do not know enough of Silurian and Cambrian life to appreciate the minutiæ of geographical distribution, since the commonest forms would stand the best chance of preservation, and these would belong to the most abundant groups. At the present time there is a better chance of capturing the locally restricted genera. Then, as regards modern animals, the tendency of research is to show that there is a remarkable uniformity and extent of range amongst the deep sea faunas. Another circumstance which would tend to mask the prevalence of local faunas is, that in comparing the Silurian creatures of one part of the world with those of another, we are comparing groups which extended over very long periods, and not the faunas as they existed during a limited period. If we were to compare the tertiary faunas of various localities, we should find something similar to what Bronn notices in the Silurian period. Perhaps, when we have to treat of the fauna of the Silurian period in an article devoted thereto, we may have occasion to recur to these points more in detail.

Our space will not permit of our examining all the subsequent faunas, details respecting which will be found under the names of the principal geological periods, such as CARBONIFEROUS SYSTEM, E. C. S.; DEVONIAN GROUP, E. C. S., &c. We will, therefore, give outlines of the general principles enunciated by Dana, and then of the laws propounded by Bronn. Dana says, the great law of the earth's development is "unity, evolving multiplicity of parts through successive individualizations, proceeding from the more fundamental onward." This applies both to the organic and inorganic world. As regards life, there has (1) clearly been progress, as manifested by the prevalence of the least specialized forms only in the earlier strata, and the preponderance of the higher groups generally in proportion as the age of the period approaches the present. (2.) This progress has not consisted of a lineal succession from a monad to a man; but by several diverging lines of progress. The type, he says, is not usually instituted by the introduction of its lowest species. (3.) The culmination of the various groups of species, or their time of greatest expansion, is not confined to any one period in geological history; but each group has its own special time, some passing it in the palæozoic, others in the mesozoic or cainozoic, and others not having reached it before the age of man. By culmination is meant the period when the highest group of the type acquired its maximum. The acrogens, he says, culminated in the palæozoic period; *Mollusca* and *Reptilia* in the later mesozoic; fishes in the tertiary period, while mammals, birds, insects, and crustaceans, are in culmination at the present time. If, however, man be excluded from the mammals, that group culminated in the post-tertiary epoch. (4.) The earliest forms of a group have a comprehensive character, that is, they combine in the same species organic characters, which are subsequently distributed amongst several species or genera, or even larger groups. Thus the earliest known birds combine certain reptilian characters along with the ornithic type, while the earliest reptiles partook more or less of the character now restricted to birds in the living fauna. (5.) The earliest types sometimes retained in maturity the character now found in the embryos of living faunas. (6.) The earliest species of a group usually belong to near the junction of its upper and lower divisions. (7.) The comprehensive types usually die out. (8.) Successive faunas and floras have a unity of character, as is exemplified by the prevalence of sessile or sedentary forms in the primordial fauna; and other examples are given. (9.) Progress always consists in the diversification of a type, involving the introduction of inferior as well as superior species. (10.) While organisms were undergoing specialization, a corresponding progress was occurring in the physical world. At first all was featureless or, as the Bible has it, without form and void, life not having as yet commenced. Then oceans and lands appeared, leading to the development of mountains and rivers. The climate was at first uniform and tropical; then zones appeared, and finally, all the variety of topographical and general climate such as is now reigning.

There is considerable similarity between Dana's general principles and Bronn's laws, which latter were the first to be published. Bronn recognizes two main fundamental laws; the first is an inherent law of development, which determines the succession of all groups above sub-orders, while the second is external to the organisms, and by virtue of it, they are subject to be influenced by the surrounding condition of the physical world. The appearance and development of sub-orders, and all smaller groups, are mainly regulated by the operation of the second law. The two kingdoms of life appeared simultaneously, and almost immediately after the commencement of aqueous sedimentary deposits, or during the primordial period, which corresponds to what we have designated upper Cambrian. At first, there were no regions of geographical distribution, the first distinct traces of which are not to be found before the tertiary period had far advanced. These earliest faunas were adapted to a climate which was tropical in its nature, and marked by few differences due to latitude or to season; diversification of climate only commenced when the central heat of the globe had ceased to have a direct effect on the temperature of the water and air which enveloped the globe. The changes of the faunas and floras were effected by the extinction of old species, and the introduction of new ones to supply their place. The changes were so effected that the faunas and floras were modified gradually, and not by the simultaneous replacement of many species by others. The transformation did not consist in modifying the old species so as to adapt them for the new conditions of life. The earliest organisms were the most widely divergent or distinct from those existing now; most of the sub-classes and orders, and nearly all the genera, were different. The number of species identical with living ones gradually increases relatively to that of extinct forms as we proceed from the oldest times onward. There have been differences due to orographical details in all floras and faunas; these details have gradually become more differentiated, and the species have also become more differentiated to adapt them for the new kinds of localities. The great forests of the coal period formed one of the most prevalent habitats of palæozoic times; they were adapted to reduce the excessive amount of carbonic acid then abounding in the air, and probably gave rise to the accumulation of carbonaceous matter at a rate far exceeding that effected in the more recent peat bogs. The alteration thus effected in the physical world probably led to a great modification in the flora. A large proportion of the terrestrial floras and faunas, including nearly all the air-breathing insects, the birds, mammals, many reptiles, and all those species which depend immediately or mediately upon the more highly specialized plants, could only have appeared after the exogenous species. Since the development of physical geography has been from ocean to islands, continents, rivers, and mountains, the earliest form must have been pelagic, then littoral, then fluviatile, and lastly, strictly terrestrial; and as a general rule, the degree of specialization of each such group is in accordance with this succession, the pelagic being the lowest, or least specialized, and the terrestrial the highest. The first terrestrial plants are of Devonian age; the first amphibious animals belong to the same period; the first terrestrial animals are carboniferous; from which period the terrestrial species gradually acquire more and more importance relatively to the marine.

The law of progressive development, or that which is inherent in the organism, is that which brings about the uniform character of each contemporaneous population, and the general balance between the various classes, and orders, and kingdoms. It is that by which the same plan or type is preserved amidst the variation and modification which is constantly in operation. It is not supposed that in following this law the lowest species were all formed before any of higher rank were introduced; or, in other words, that the *Protozoa* were created in their full development, then the *Cœlenterata*, and so on, with the other sub-kingdoms. This is disproved by the occurrence of all the four invertebrate sub-kingdoms in the primordial fauna. But it is supposed that the first individuals of each type were the most imperfect, and were the starting points of ascending series, which gradually attained their highest degree of perfection. This mode of progressive development is more clearly illustrated by plants, which commenced with the simultaneous existence of three sub-kingdoms, to which other sub-kingdoms succeeded in regular order according to their systematic rank. The two highest sub-kingdoms, which comprise all the highest dicotyledonous flowering plants, first appear in the tertiary period, and in succession. The late appearance of these groups, which predominate in all existing floras, would explain the late appearance of the great majority of terrestrial animals. This statement would require modification now, since flowering plants were existing in the cretaceous period, and hymenopterous insects allied to bees flitted about in the oolitic atmosphere. Progressive development does not consist merely in the association of the more perfect types with the less perfect pre-existing ones, but also in the partial or total extinction of the types which have passed their period of maximum, and in the expansion of the later and more perfect type.

These laws, Bronn observes, undoubtedly exist, but they are by no means to be regarded as being of so inflexible a nature as the law of gravitation and other physical laws which allow of no variation. Although there has been in the main a uniformly ascending series, there are two well recognizable culminating points, one of which occurred at the close of the palæozoic epoch, and the other at the commencement of the tertiary period. The first is marked by the cessation of the great marshy coal forests and the extinction of a great number of palæozoic types; and the last by the extinction of ammonites and belemnites, the development of dicotyledons, the more rapid augmentation in the number of genera and species, and the first traces of diverse climates, which events were, however, gradually and successively evolved. As before stated, the establishment and extinction of species has been continuous, and accomplished in a uniform way, although at times the rate of modification was influenced to a slight degree by various geological events. The duration of species has varied much amongst themselves, some having lasted five times longer than others, while a few have prolonged their existence through one or even two geological epochs. If similar kinds of deposits last longer in one place than another it may be expected that the organisms will last in some localities longer than others. If such deposits are interrupted and renewed on the same site, the same group of beings may recur. But it frequently happens the same species continue with little alteration in their relative abundance through a succession of heterogeneous deposits. The instances are very rare in which two beds forming the contiguous strata in the geological column, as far as known, have not some species in common; in a few cases the palæontological gap is complete as regards species. The duration of the same fauna or flora was, generally, considerable; but usually the succession of beds containing the evidence of its history are so few that the successive events, which were really separated by long intervals, appear to have followed one another rapidly, or even simultaneously. The present condition of the organic world indicates the continuance of the actions which were in operation in the immediately preceding period, those families continuing to diminish which had commenced their decline in the later portion of the tertiary epoch, and those groups spreading and expanding which were then on the increase. In the latest tertiary deposits the faunas and floras have the same general distribution as now prevails. As to the question whether man, who is said to be the last species created, was associated with any of the extinct species whose disappearance did not occur within the historic period, Bronn decides that it is doubtful. True it is that his bones are associated with those of extinct mammals, but the deposits which contain them have been accumulated by water from the denudation of older beds, so that the contemporaneity of the human with the other bones is open to question.

Such is a very rapid sketch of the laws propounded by Bronn, which, we may add, are abundantly illustrated by facts, in his elaborate and bulky Memoir cited at the foot of this article. We have noticed it because it is the most complete and exhaustive work of its kind, but we suspect that most of the conclusions are erroneous. At present, it seems that only a few of the broader principles are sound, such as the evolution of multiplicity out of uniformity; the general progress from generalized to specialized structures by a complex system of ramification, and by the simultaneous development of many branches. It would require far more labour and time than we have at our disposal to bring together the multitude of facts which would be required to demonstrate in what Bronn has gone astray, and what the true laws or general principles for the regulation of the progress of life have been; but we conceive that the idea suggested by him that the modifications in the forms of life are correlated with, or rather have depended upon, the modifications in the conditions subject to which that life has been carried on, is a very fruitful one. One important element in the discussion would be the influence of these conditions in modifying form and structure; and this is intimately connected with the mode in which species have originated. According to Bronn, the evolution of a type has been effected by the formation of a succession of species without any genetic relationship; but it is quite as harmonious with observed facts to suppose that the evolution has been by a succession of species which are genetically related; or it may be that both modes of operation have been employed. To our minds, there are fewer difficulties on the assumption of the second mode; but all the modes are equally in accordance with the conviction that species are created according to law, not by chance. Surely there is nothing in the account in Genesis inconsistent with the idea of the evolution of organisms by genetic relationship, and certainly the proposition does not deserve to be sneered at as irreligious. We are fully impressed with the general undesirability of referring to sacred subjects in the discussion of scientific matters, but this is merely because it rouses an acrimonious and intolerant feeling which ought never to exist between two sets of men whose main object in life is the elucidation and dissemination of truth. We believe the true Christian and the true scientific man can never descend to mere wrangling, but that any ill-feeling that may arise is due to want of tolerance, to misunderstanding, and the influence of motives other than the highest. In referring to the Bible in this place the reader may be assured that we do so with the utmost reverence; but at the same time we must avow that we cannot place implicit faith in the absolute truth of anything which has proceeded from the hand of man. With this proviso, we willingly express a conviction that the account of the cosmogony in the first chapter of Genesis is the nearest approach we know of to an accurate general account of the past history of the globe based solely upon scientific considerations. The true meaning of the chapter appears, however, to be difficult to catch, owing partly to the obscurity of the language as conveyed in a translation, and partly to our own ignorance. As we understand it, it appears that the whole account refers more especially to the earth (or rather its surface) and its inhabitants; so that it does not carry back the history of the universe prior to the formation of the earth. At first the globe was a chaotic mass enveloped in an universal ocean of water and gas so dense as to wholly exclude the light of the universe. When it was said, "Let there be light," the gaseous envelope became transparent; and by further changes this envelope was converted into the firmament, which we cannot express the meaning of more approximately than by calling it the lower region of the atmosphere. The next changes brought about the collection of water into basins, and the appearance of dry land, which may be attributed to the condensation of the vapour in the atmosphere into seas, and the contraction of the earth forming elevations and depressions under the influence of decreasing temperature. The introduction of plant life followed, when as yet the intensity of the light was very feeble. It was not till after the introduction of plants that the full light of the sun, moon, and stars shone upon the earth. The passage relating to the fourth day's work has its difficulties, since it almost seems to imply that the sun, moon, and stars were then created. The correct interpretation we conceive is that the atmosphere was then first modified so as to render it transparent to the solar, lunar, and stellar rays. When the light came forth in all its splendour the fiat was issued for the appearance of animals, the marine and aquatic species leading the way, to be followed by the terrestrial species; and lastly, man crowned the whole. And now we come to a matter upon which we would speak less confidently. The chapter appears to consist of two parts, viz., the fiats of God, and the remarks of the inspired writer. If we confine our attention to the former, it is noticeable that the chronicle asserts that each important change was preceded by a distinct enunciation of Divine Will, as implied by the phrase "Let there be." This we take it means that each of the set of creations was brought about by the establishment of laws, or by the special application of laws previously in operation; and that the successive acts of creation were the successive establishment of sets of laws by virtue of which the things became what they are. The work of each period, and the succession of the periods, then, refer to the establishment of the laws, rather than to the acts of creation as such. The latter commenced in the periods assigned to them, but they continued through the succeeding periods, so that after the last period, when man appeared, no new terrestrial laws were framed, but all the acts of creation continued simultaneously in operation, and still continue at the present hour.

Having thus paraphrased the earliest of palæontological writings, we return to the subject which suggested what some may deem to be a digression, viz., the way in which species have been originated. Such a subject will be more appropriately discussed in a subsequent article devoted to species. If the evolutionary hypothesis be correct, it may be said that the species are modified at a rate corresponding with the intensity of the modifying influence. The rate of change as evidenced by fossils varies considerably, according to the genus or family, or other kind of group. In many cases, it is remarkable how slow is the rate when compared with the duration of man. Thus, some species have continued with no appreciable difference from as far back as the beginning of the tertiaries, or even the end of the cretaceous period, while many genera have lasted from the palæozoic period to the present day. On the other hand, nearly allied genera have changed since the last mentioned period several times over; that is, supposing such genera to have been successively evolved out of one another, their united durations would not exceed the time from the Silurian epoch to the present. As an indication of how the several groups of beings have differed in the rate of their modification during past time, we give a table, condensed from one of Bronn's, in which is shown what proportions of the genera of each period are now extinct. The figures are based upon the data known in 1855; but, although more recent researches might modify some of the details, the general result would not be materially altered.

TABLE SHOWING THE PER CENTAGE OF GENERA EXISTING DURING EACH PERIOD WHICH HAVE BECOME EXTINCT.

	Plants.	Protozoa.	Cœlenterata.	Mollusca.	Articulata.	Fishes.	Reptiles.	Birds.	Mammals.
Cainozoic . .	58	27	47	16	14	53	33	13	60
Cretaceous .	93	34	73	33	32	81	80	—	—
Jurassic . .	100	22	80	36	43	97	88	—	100
Triassic . .	100	37	79	36	46	100	96	100	100
Palæozoic . .	100	65	98	61	96	100	100	—	—

From this table it appears that while in some groups all the palæozoic genera have died out, yet that in some others, such as the *Protozoa* and *Mollusca*, a large proportion of the genera have endured till now; while of the triassic genera belonging to the same sub-kingdoms the majority are still in existence. These figures imply that when a genus is once established, it usually persists for an immense length of time, and that probably their average duration in some classes would not be over-estimated at several millions of years. If the doctrine of the evolution of species by genetic relationship implied that the new forms took the place of the old genera from which they were derived, it would be almost impossible to admit that the doctrine is true, because the rate of change has been so slow as to demand far more time than could reasonably be allowed. The next table also has its figures based upon old material, but even if corrected up to the present state of knowledge it would not, we believe, modify the general conclusion we shall draw from it. It represents the development of the families, genera, and species of *Mollusca*, and is borrowed from Woodward's 'Manual of Mollusca.'

	Families.		Genera.	Species.
Palæozoic:				
Cambrian	18	32	49	362
Silurian	20		53	317
Devonian	24		77	1035
Carboniferous . . .	30		79	835
Permian	30		66	74
Secondary:				
Trias	35	57	81	713
Lower Jurassic . .	42		107	1502
Upper Jurassic . . .	49		108	1266
Lower Cretaceous . .	52		123	784
Upper Cretaceous . .	56		148	2147
Tertiary:				
Eocene	60	78	172	2636
Miocene	60		178	2242
Pliocene	62		192	437
Recent	78		400	16,000
Recent and Extinct . .	85		520	30,000

The most remarkable facts brought out by this table are the constantly augmenting number of the families and genera, and the small proportion which have died out. Thus, out of 85 families, which are all that are known, only 7 families, that is, 8 per cent. have died out; of the genera, 120 have died out, forming less than 25 per cent. of the total number. The number of species fluctuate too much to warrant any general observation, and the fluctuation is in great measure due to the numbers representing fragments only of the total aggregate faunas of each period. The gradation in the figures is such as would harmonize with the view that the greater variety of the fauna of each period over that of the preceding period has been effected by the evolution of the new types from the old ones, and the continued modification of the great majority of both the primary and secondary types. Hence the expansion of a class or large group is regulated partly by the rate of change, and partly by the number of lines of evolutionary modification. In this case, the rate of change would be quite fast enough to harmonize with probable estimates of the length of geological time.

In the article ORGANIC REMAINS, E. C., a series of numerical tables are given, indicating the proportion between the fossil and recent species. We have purposely avoided giving many figures in the preceding part of this article, because it is difficult to obtain numerical estimates in accordance with the present state of our knowledge, and because such figures are constantly undergoing alteration, both as regards the absolute numbers and the relative proportion of the recent and fossil species. The most complete general tables are those of Bronn's, which, however, only include the materials known up to various periods from 1850 to 1856. We would warn the reader not to place too high a value on such tables, but as it may be desirable to supplement those already given in the E. C. by others of a less antiquated character, we append the following:—

NUMBER OF FOSSILS AND LIVING SPECIES KNOWN IN 1856.

	Total fossils.	Palæozoic.	Triassic.	Oolitic.	Cretaceous.	Tertiary	Living.
Cryptogamia:							
Cellulares	442	40	4	61	51	286	10,187
Vasculares	1221	872	80	122	65	82	2346
Phanerogamia:							
Monocotyledoneæ	301	20	8	22	19	232	13,952
Dicotyledoneæ:							
Gymnospermæ	533	77	21	144	68	223	356
Angiospermæ:							
Monochlamydeæ	593	—	—	—	30	563	4866
Dichlamydeæ:							
Polypetalæ	596	—	—	—	4	592	32,697
Gamopetalæ	165	—	—	—	—	165	28,258
Total	3851	1009	113	349	237	2143	92,662

The proportion which the fossil species bear to the living is as 1 to 24, which is very much higher than appeared from the data known to Brongniart, about 28 years previously; and doubtless the proportion is much higher according to present materials, since the rate of discovery of new fossil species is greater in proportion to the whole number than of new recent species. But it is incredible that the number of species in existence can be 24 times greater than the whole number that have existed in all past geological time. Various considerations render it highly probable that if the fossil species could be as easily and completely collected as the living floras, the total number of the former would exceed the latter. There is scarcely a doubt that the palæontological record is exceedingly imperfect, more so than is usually admitted, so imperfect that we have not found one-twentieth of what once existed. Bronn estimates the number of living species of plants known in 1855 at 100,000, and of animals, at 120,000. Both are certainly very much below the proper figure at the present time. As regards plants, we are not in a position to form a good estimate, but we think the number must be over 150,000. As regards animals, the total does not fall short of 500,000. These figures, although large, are considered by good authorities to be short of the actual number of species actually existing. De Candolle estimates the probable number of plants at 200,000 for the *Phanerogamia*, and a somewhat smaller figure for the *Cryptogamia*. So that, even as regards living beings, which are far more accessible than the extinct species, the list is anything but complete. This is manifest, when it is considered what a stream of new species and genera fall into the ocean of scientific literature every year; the number of new living species of animals described annually averages over 5000.

In the table which follows, a condensed summary is given of Bronn's tables, mainly from his later general work on Zoology, so as to show the number of species known in each of the principal periods, and still living.

	Fossil.	Palæozoic.	Triassic.	Jurassic.	Cretaceous.	Tertiary.	Living.
Protozoa	2533	43	49	119	585	1737	1770
Cœlenterata :							
Actinozoa	1408	384	23	304	418	278	1033
Hydrozoa	—	—	—	—	—	—	476
Annulosa :							
Echinodermata	2262	503	35	652	615	457	772
Annelida	343	42	11	72	103	115	770
Crustacea	1097	544	15	184	82	272	905
Myriapoda	—	—	—	—	—	—	—
Arachnida	140	2	—	3	—	135	800
Insecta	1827	8	—	134	—	1685	65,000
Mollusca :							
Polyzoa	1691	73	—	116	1100	402	571
Tunicata	—	—	—	—	—	—	264
Brachiopoda	1937	1303	59	293	144	59	84
Lamellibranchiata	7250	918	3370			2958	4398
Pteropoda	136	117	—	—	—	19	84
Gasteropoda	7383	737	393	497	446	5310	8800
Cephalopoda	1731	772	106	547	509	37	127
Vertebrata :							
Pisces	1828	449	90	400	285	606	8000
Reptilia	523	39	66	140	43	235	1055
Aves	206	4	30	1	1	170	7000
Mammalia	900	—	1	4	2	893	2050
Total	33,195	5938	—	—	—	14,768	102,114

The proportion between the fossil and living species is as 1 to 3; a result similar to what was obtained in the case of plants, inasmuch as the proportion has been increased, and is being gradually raised, by continued research. It would be easy to point out many defects in the table, but there are very few who could construct one up to the present state of knowledge. Thus, as illustrations, we may notice that Bronn recognizes 180 genera amongst living annelids, and 770 species; but at the present time the genera are over 300, while the species may be estimated at a much higher figure than he gives. The *Myriapoda*, of which no fossil species were known to Bronn, are now represented by at least half-a-dozen carboniferous species. Bronn recognizes but eight palæozoic insects. In the articles CARBONIFEROUS SYSTEM and DEVONIAN GROUP in E. C. S., about two dozen species are indicated, which have been discovered since 1855. Great additions have been made to our list of carboniferous reptiles, which would materially modify Bronn's figures. His number of living species must have been under-estimated even in 1855. At the present time the Paris Museum alone has more than 1550 species, and that is by no means complete, as indicated by comparing the numbers of the smaller groups with other lists and estimates. Thus, the Paris Museum has 619 species of snakes, while the British Museum had 827 a few years ago. Again, the Paris Museum had 187 species of tailless batrachians, while the number hitherto described is over 260. Judging from details of this kind we do not think that the total number of living reptilian species can be under 3000. As regards the birds, the mention of four palæozoic species is clearly an oversight; the figure is mentioned in the table we have consulted, but in other portions of the memoir it is indicated that there are no birds of this age. The triassic species are based upon footmarks, and it is probable that most, if not all, are really reptilian [BIRDS, E. C. S.]. The number of jurassic mammals is at least two dozen. However, as we have already said, it is easy to notice a few defects, but far more difficult to remedy all.

In the table on the distribution of the vertebrates in col. 118 of the article ORGANIC REMAINS, there are many modifications required, which may be indicated without drawing up a new table. These changes consist mainly in carrying the existence of several classes to an earlier period. Thus, the *Acalephæ* are known to be as old as the oolitic period, an interesting fact, since it points to the possibility of finding the remains of the soft-bodied animals even in the oldest strata. The *Annelida* and *Foraminifera* date from the oldest deposits; the *Myriapoda* are known to be as old as the carboniferous period; and the *Pteropoda* have been discovered in palæozoic beds. As to the table relating to vertebrates in col. 119, little change is required; the occurrence of reptiles in carboniferous beds is beyond a doubt; and what may be the indications of birds have been discovered in the triassic strata. Another feature which seems to be implied in the tables just referred to, is that below all the fossiliferous strata there are others which are azoic. In the present state of science it would be preferable to discard the idea of azoic rocks, that is, strata which were deposited before life began; since it is certain that no one has demonstrated that any such group of strata have been discovered; and since we ought not to overrate the importance of what has been done as compared with what is yet to do. The general impression which a survey of palæontological science leaves upon the mind is that it is in its infancy, and that when fully developed it will be far vaster in its scope than modern zoology, inasmuch as the life of the living fauna is of very short span as compared with the immense period over which the many generations of past species have extended. It is a difficult matter to demonstrate what proportion of the palæontological record is wanting, but there are various ways in which a rough guess may be arrived at. D'Orbigny arranged all the strata known to him into thirty formations, corresponding to so many geological periods. The first period was the Tremadocian, corresponding to what is usually termed the Cambrian, and the last the Icenian, corresponding to what is more commonly known as pliocene. Taking the *Mollusca* as a standard, the rate of change is such that on an average a species lasts through one-third of a formation; and a genus endures through four formations or periods. The strata known to D'Orbigny do not comprise the whole geological column. First of all, there are gaps; and D'Orbigny estimated that on an average the sea prevailed in a locality for two-thirds of each period, and the land one-third. Then there is the small addition corresponding to the time which has elapsed since the pliocene; and the large addition answering to the pre-Cambrian strata. Under Limestone, E. C. S., we have pointed out the probability that calcareous accumulation has been not only constant, but continuous, so that were a complete survey of geological strata practicable, the whole range might be represented by the limestones which had succeeded one another. Such a column we estimated at 50,000 feet, of which 27,000 corresponds to D'Orbigny's thirty periods, and the whole thickness would answer to fifty-five such periods. As the calculation does not pretend to be accurate, we may consider 1000 feet of limestone to be equivalent to a formation or a period; that on the average a species lasts while 330 feet of limestone are accumulating, and a genus while 1300 feet are forming. In such case the number of species that would have succeeded one another from the earliest Laurentian to the present time is 150, and of genera about 40. We do not know what the rate of increase of genera or species is, but in the case of the former groups in *Mollusca* it is known that there is a constant augmentation in the number of known forms, such that while fifty genera were co-existing in the Cambrian period the number in the pliocene period was nearly 200; this length of time corresponds to a succession of about twenty genera. If the development of genera is effected, by genetic evolution with diversification the rate of change indicated is 14 per cent. for every 1300 feet of limestone, or the period equivalent thereto; or in round numbers 10 per cent. per genus for every period answering to the deposition of 1000 feet of limestone. As species succeed one another four times more rapidly than genera, we may guess their rate of change to be 40 per cent. per species per period. Assuming that the rate of change in *Mollusca* represents the rate at which animals generally have changed during the period which has elapsed from the time of the Laurentian strata to the present day, it would be amply sufficient to allow for all the variation which is now manifest. Thus, in order to illustrate our idea, we will work out an imaginary calculation, and assume that a divergence amounting to six times that which constitutes a species forms a genus; we assume also that a species belonging to each of the four invertebrate sub-kingdoms existed in the Laurentian period; that fishes commenced in the Silurian, reptiles in the carboniferous, birds in the triassic, and mammals in the oolitic periods. Starting then with four species, the change would cause the number at the end of the first period to be five, and an amount of divergence nearly equal to a sixth; at the end of the second period the number would be nearly eight; and so on. At the end of the Laurentian period there would be 113 species; at the end of the Huronian, 1229 species; 45,000 at the end of the Cambrian; and over a million at the end of the silurian. If we were to carry the calculation up to the present time, the total would be some millions of species. Although these calculations are based so largely upon assumed premises, we believe they are worth consideration, since they show how slow a rate of change will suffice to produce the present amount of variety and divergence; a rate such that from 700 to 800 feet of strata might be deposited before a species would develope a second. As yet we have said nothing as to time, which is an important point to know in order to ascertain whether the above conclusions are inconsistent with what is taking place in the world around us. That the accumulation of 800 feet of strata must occupy a long space no geologist will dispute. Suppose we take Sir W. Thomson's estimate to be correct, then the 50,000 feet of limestone would correspond to 500 million of years; and each 1000 feet, or each of the fifty periods corresponding thereto, would represent an epoch of ten million years; and the average time required for the evolution of one species from a second, upwards of three million years. Do the facts known as to the mutability of living species negative the possibility that species, on the average, do not change by the $\frac{1}{5{,}000{,}000}$th part of a specific amount of difference in the course of a single year; or that a species may have altered by the $\frac{1}{500}$th part of the same amount during the last 5000 years? We will not answer these questions, but under Species, E. C. S., allusion will be made to some of the changes which have been observed in species.

(Bronn, *Comptes Rendus*, *Supp.*, tome ii. pp. 377—918, 1861; Bronn, *Die Klassen und Ordnungen der Thier-reichs*, Band. 1, 2, and 3; D'Archiac, *Géologie et Paléontologie*, 1866; Dana's *Manual of Geology*; &c.)

PALAMEDEA [Chauna, E. C. S.].

PANGENESIS is a provisional hypothesis, or an attempt to explain by *a posteriori* ratiocination the method or methods by which the observed phenomena of growth and development in organic beings are effected. The premises which are proposed as the basis of reasoning are that an organism is wholly composed of cells or molecules; that these cells or organic units differ from one another according to the function of the organ to which they belong; that these units are constantly undergoing multiplication by budding or proliferation during the whole period of their existence, giving rise to multitudes of excessively minute atoms, particles, or gemmules, which are diffused in greater or less abundance, and to a greater or less extent throughout every portion of each organism; that the properties of a unit are liable to be modified by surrounding conditions; that the gemmules possess the properties which the unit had at the time they were thrown off; and that when these gemmules are exposed to suitable conditions they give rise to the same kind of cells from which they were themselves derived. In the simplest organisms, in which the functions are manifestly few in number and obscurely developed, the distinct kind of cells are also supposed to be few in number, and but slightly different one from another. In the most complex organisms, in which structural and functional differences are numerous, and in which many organs can be easily demonstrated, it is supposed that the number of distinct kinds of units are correspondingly numerous and diversified. The growth of an organism consists of the multiplication of the units or cells without material alteration in their relative numbers; development consists partly of an alteration in the numerical ratios, and partly of the incorporation of new kinds of cells, owing to the gemmules having met with the conditions adapted for the growth of such cells. It is supposed that the gemmules are diffused everywhere through the tissues ready to evolve the particular kind of cell represented by them whenever the conditions under which the original cell flourished recur. It is supposed the gemmules have the power in some way of transferring the property of the cell long after the death of the original cell, remaining in the meantime in a dormant condition. It may be suggested that the gemmules multiply without giving rise to cells, since it is contrary to analogy to suppose that the same gemmules can exist for generations. It is also supposed that certain gemmules have a mutual attraction one for the other, so as to collect together into little aggregate groups. It is also supposed that the number of each kind of gemmule fluctuates according to circumstances, and, so far as we can gather, that the kinds of gemmules are liable to extinction.

By means of these suppositions Darwin explains many remarkable phenomena, whether they are normal, that is, of ordinary occurrence, or abnormal, that is, of extraordinary occurrence. Organisms, as is well known, commence in a minute speck, which has no apparent distinction of parts and performs no functions. In their mature state we can perceive distinct parts and witness the execution of functions. First of all the cells are apparently similar; as development proceeds the mass of the organism increases in bulk, and at rapid intervals new kinds of cells appear and rapidly multiply. The complexity of the result varies according as the organism is a monad or a man. In this imaginary evolution we have an excellent illustration of what Bronn declares is the law of progress on this earth, viz., that simplicity of parts is evolved out of unity through successive individualization, proceeding from the more fundamental onward. We also have a parallel set of phenomena to the progress of life. In the one case the change is rapid, in the other slow. We shall not allude to the many curious facts afforded by the various modes of reproduction, the metamorphoses of animals, the reversion of individuals to some antecedent parent form, the occurrence of monstrosities, &c., and the way in which they may be partially accounted for, but would refer the reader to Darwin's work on 'The Variation of Animals and Plants under Domestication.' In order, however, that the scope and applicability of the hypothesis may be perceived, we will give the author's condensed outline of it. "The hypothesis of Pangenesis as applied to the several great classes of facts just discussed, no doubt is extremely complex; but so, assuredly, are the facts. The assumption, however, on which the hypothesis rests, cannot be considered as complex in any extreme degree, namely, that all organic units, besides having the power, as is generally admitted, of growing by self-division, throw off free and minute atoms of their contents, that is, gemmules. These multiply and aggregate themselves into buds and the sexual elements; their development depends on their union with other nascent cells or units; and they are capable of transmission in a dormant state to successive generations. In a highly organized and complex animal the gemmules thrown off from each different cell or unit throughout the body must be inconceivably numerous and minute. Each unit of each part, as it changes during development—and we know that some insects undergo at least twenty metamorphoses—must throw off its gemmules. All organic beings, moreover, include many dormant gemmules derived from their grandparents and more remote progenitors, but not from all their progenitors. These almost infinitely numerous and minute gemmules must be included in each bud, ovule, spermatozoon, and pollen-grain. Such an admission will be declared impossible; but, as previously remarked, number and size are only relative difficulties, and the eggs or seeds produced by certain animals or plants are so numerous that they cannot be grasped by the intellect. The organic particles with which the wind is tainted over miles of space by certain offensive animals must be infinitely minute and numerous; yet they strongly affect the olfactory nerves. An analogy more appropriate is afforded by the contagious particles of certain diseases, which are so minute that they float in the atmosphere and adhere to smooth paper, yet we know how largely they increase within the human body and how powerfully they act. Independent organisms exist which are barely visible under the highest powers of our recently improved microscopes, and which probably are fully as large as the cells or units in one of the higher animals; yet these organisms no doubt reproduce themselves by germs of extreme minuteness, relatively to their own minute size. Hence the difficulty, which at first appears insurmountable, of believing in gemmules so numerous and so small as they must be according to our hypothesis, has really little weight. The cells or units of the body are generally admitted by physiologists to be autonomous, like the buds on a tree, but in a less degree. I go one step further, and assume that they throw off reproductive gemmules. Thus an animal does not, as a whole, generate its kind through the sole agency of the reproductive system, but each separate cell generates its kind. It has often been said by naturalists that each cell of a plant has the actual or potential power of reproducing the whole plant, but it has this power only in virtue of containing gemmules derived from every part. If our hypothesis be provisionally accepted, we must look at all the forms of a sexual reproduction, whether occurring at maturity or as in the case of alternate generation during youth, as fundamentally the same, and dependent on the mutual aggregation and multiplication of the gemmules. The re-growth of an amputated limb or the healing of a wound is the same process partially carried out. Sexual generation differs in some important respects, chiefly, as it would appear, in an insufficient number of gemmules being aggregated within the separate sexual elements, and probably in the presence of certain primordial cells. The development of each being, including all the forms of metamorphosis and metagenesis, as well as the so-called growth of the higher animals, in which structure changes, though not in a striking manner, depends on the presence of gemmules thrown off at each period of life, and on their development at a corresponding period, in union with preceding cells. Such cells may be said to be fertilized by the gemmules which come next in the order of development. Thus the ordinary act of impregnation and the development of each being are closely analogous processes. The child, strictly speaking, does not grow into the man, but includes germs which slowly and successively become developed and form the man. In the child as well as in the adult, each part generates the same part for the next generation. Inheritance must be looked at as merely a form of growth, like the self-division of a lowly organized unicellular plant. Reversion depends on the transmission from the forefather to his descendants of dormant gemmules, which occasionally become developed under certain known or unknown conditions. Each animal and plant may be compared to a bed of mould full of seeds, most of which soon germinate, some lie for a period dormant, whilst others perish. When we hear it said that a man carries in his constitution the seeds of an inherited disease, there is much literal truth in the expression. Finally, the power of propagation possessed by each separate cell, using the term in its largest sense, determines the reproduction, the variability, the development, and renovation of each living organism. No other attempt, as far as I am aware, has been made, imperfect as this confessedly is, to connect under one point of view these several grand classes of facts. We cannot fathom the marvellous complexity of an organic being, but on the hypothesis here advanced this complexity is much increased. Each living creature must be looked at as a microcosm—a little universe formed of a host of self-propagating organisms, inconceivably minute, and as numerous as the stars in heaven."

PARISITE [E. C. vol. iv. col. 210]. A mineral first found in the emerald mines of the Muso valley, New Granada. It crystallizes in double six-sided pyramids, with truncated apex; and has a very perfect basal cleavage. Its hardness is 4·5; its specific gravity, 4·3; its colour brownish-yellow; and its streak yellowish-white. In the earlier analyses by Bunsen it was supposed that water formed an essential constituent, but from the analyses of Damour and Deville in 1864 it would seem that the water is accidental. According to the last-mentioned chemists the composition is :—

Carbonic Acid	23·48	per cent.
Cerous Oxide	42·52	,,
Protoxide of lanthanium . .	8·26	,,
Protoxide of didymium . .	9·58	,,
Lime	2·85	,,
Fluoride of calcium . . .	10·10	,,
Fluoride of cerium . . .	2·16	,,
Manganous oxide . . .	tr.	,,

(Watts' *Dictionary of Chemistry*, art. *Parisite*; Dana, *A System of Mineralogy*, 5th edition, p. 702.)

PELTOCARIS, a genus of phyllopodous crustaceans, of which remains have been found in the lower silurian shales of Dumfriesshire. It was established in 1861 by Mr. Salter, who defines it as being "a small phyllopod, with a round shield-shaped carapace; bivalved, the valves open, and imperfectly joined along the dorsal lines; deeply emarginate in front, the excavation so formed being filled up completely by a parabolic plate, which is the analogue of the rostrum, and completes the broad oval shield." He describes two species, viz., *P. aptychoides* and *P.* (?) *Harknessi*. In discussing the affinities of the genus, he refers to a series of generic forms, which succeeded each other from the *Lingula* flags up to the present time, and which seem to indicate a gradual modification. In the earliest genus, or *Hymenocaris*, the shield is in one piece, arcuate, and without a rostrum; the body segments are numerous, and have an aggregate length equal to that of the shield; and the appendages to the tail are irrelatively multiplied. In *Peltocaris* the shield is marked out into three portions, but the valves remain open, and not approximated towards each other. From various curious markings on the shales, which are conjecturally assigned to *Peltocaris*, the tail is believed to have had fewer appendages than in *Hymenocaris*. In *Ceratiocaris* of the upper silurian the shield is tripartite; the valves are movable, and partly enclose the body; the rostrum still remains distinct from the carapace; the number of tail appendages is three; and the ratio between the length of the free body segments and of the shield is the same as in *Hymenocaris*. Above this horizon the larger phyllopods, including *Leperditia* and its allies in this group, form two groups. In one the carapace becomes more decidedly shield-shaped, the free abdominal segments fewer in number, but still exserted, and the caudal styles two in number. In the other the carapace becomes completely bivalved, so as to enclose all the abdominal segments and their appendages. He gives a series of figures illustrative of this idea of succession, and makes the following remarks respecting them :—"I do not think, judging by the carapace only, that many links are wanting between the Llandeilo-flag *Peltocaris*, and the upper silurian *Ceratiocaris*. But there is evidently a still nearer connection (probably we want an intermediate Devonian form) between *Ceratiocaris* and *Dithyrocaris*. The *Argas* of the lower carboniferous rocks, and a huge bivalve crustacean (*Dithyrocaris pholadomya*), not here described, were close relations of the *Dictyocaris* and *Ceratiocaris* of the upper silurian, differing only in having the anterior joints of the abdomen concealed, and the rostrum minute, or possibly (but not probably) absent. The links between these coal measure forms and those of recent times are many of them wanting; but in *Nebalia* we have a good representative of the compact, shield-shaped form of *Ceratiocaris*, the two valves soldered into one, and the rostrum attached, the eyes being still beneath the carapace. *Apus* is the most complete and decided form, and it is one of the latest of this group, since it commences in the trias. The abdomen is not only greatly increased, and the caudal styles elongated beyond the telson, but the styles are jointed appendages; and the feet and antennæ have also taken on a development wholly beyond that of the rest of the order.

The other group, the truly bivalved and enclosing phyllopods, do not present the same variety of forms. From the period of the middle Devonian, where *Estheria* first makes its appearance, till now, there has been but little change, except a gradual increase in size. And as I do not feel sure that we have in the *Estheria* or *Leperditia* the oldest member of the series, I will only place them as they stand in the diagram, and abstain from discussing the affinities of any but the larger and shield-bearing phyllopods. I may be permitted to say, that even of these the series, as here exhibited, is not quite satisfactory in a Darwinian point of view. The transition, if it be such, from *Hymenocaris*, with an entire shield, to a form with sutures, and then valves, returning afterwards to a more completely soldered and compact form, may be regarded as an oscillation of character by those who do not see a more embryonic representative in the thin undivided carapace (without rostrum, suture, or external eye) in the primordial form. *Apus*, however, is unquestionably the most highly developed; and it is the latest."

(Salter, J. W., *Quart. Journ. Geol. Soc.*, vol. xix. p. 87—95.)

PENARTH BEDS. [Rhætic Beds, E. C. S.]

PENTREMITES. [Blastoidea, E. C. S.]

PERMIAN GROUP, a set of beds, of which a notice was given in E. C. under Magnesian Limestone; but this latter term is seldom used, and is objectionable as being based upon peculiarities which are purely local. It is occasionally called *Dyas* by the Germans, in allusion to its being composed in some countries of two distinct and strikingly characterised series of stratified beds, but this term is objected to by Sir R. I. Murchison, on the ground that although in some places there is a twofold arrangement, yet in many others where the beds are best displayed and developed, the arrangement has an eminently triple character.

This group of beds possesses many features of especial interest to the geologist, the most of which we shall be compelled to pass over with slight allusions, although worthy of more deliberate attention. Those which will chiefly be noticed here are more or less connected, in appearance or in reality, with the subject which was just mentioned under Boulders, E. C. S., and a reference made therefrom to the present heading for further details. That subject is the occurrence of scratched angular blocks of rock in Permian beds. Such blocks are believed by some geologists to be ice-transported boulders; so that the principal question which comes before us for discussion is whether there are any grounds for suspecting the existence of glaciers or of a glacial epoch during the Permian period.

Wherever the Permian beds occur in Europe they rest unconformably upon older rocks, frequently upon coal-measures, but in very many cases transgressively upon strata of almost any antecedent formation. In like manner they repose unconformably beneath all the rocks that have yet been seen above them. In America, however, as we shall presently notice more fully, the carboniferous strata pass conformably, both as regards life and stratification, into the Permian series; but between this series and the next overlying deposits there is a considerable gap. The Permian rocks are usually situated in low lying tracts relatively to older strata; that is to say, they occur on plains and on the flanks of highlands, whose upper portions are composed of older strata. The arrangement indicates that before the Permian beds were formed the earlier deposits had been disturbed from their original horizontality, elevated into lofty regions, and possibly carved out into depressions. For a long time preceding the Permian period the eruption and intrusion of volcanic or igneous materials appear to have been only of moderate activity, but the period itself seems to have been ushered in with a marked intensity of volcanic activity. The lithological characters of the beds themselves vary in minor details, as also in the degrees to which the subordinate members are developed, but looked at as a whole, there is a general uniformity in the order of succession. That order is first a series of red arenaceous beds, next limestones, marls, and gypsum, and lastly arenaceous beds again, generally red. In order to illustrate this remark, as also to indicate that the variations which occur are compatible therewith, we will notice the deposits of one or two localities. In the Thuringerwald the Permian beds are of immense thickness, and have been proved to be several thousand feet in vertical extent, and even then the base has not been reached. The lowest beds belong to the lower of the three members into which the Germans have divided this group of beds, or the Roth-todt-liegende. Beginning from the base, we first find a rock fully 600 feet thick, but considerably denuded in places. It is a breccia composed of angular fragments of older rocks inclosed in a red matrix; and Murchison says of it that this and the other "so-called conglomerates of this age in many parts of Germany are essentially angular breccias, which could not have been formed by the action of rolling waves on a shore, but must have been tumultuously and suddenly heaped together." It is succeeded by 250 feet of dark red shale and sandstone, and this is in its turn overlain by 500 feet of a breccia partially composed of masses of a granite not known in the Thuringerwald, nor in any place nearer than the Hartz. The last rock graduates upwards into a light gray conglomerate, which becomes gradually more and more calcareous towards its summit, so as to pass into a cupriferous bed, the well-known Kupfer Schiefer, the thick-bedded Zechstein, and dolomitic layers, the Stinkstein, associated with gypsum. Red shales and sandstones cap the series. The masses of gypsum are in many instances local metamorphoses of limestones, whereby these have been converted from stratified bands of carbonate of lime into amorphous largely swollen bosses of sulphate of lime. In the Hartz district also the Permians consist of red sandstones and conglomerates below, calcareous rocks in the middle, and other red sandstones above. In some places in this area, as at Altenstein, it is observable that the huge hills of dolomite, without any signs of stratification, are the continuation of the bedded Zechstein; a fact which is shown by their being on the line of strike, and containing the same fossils. In the more southern German localities the Zechstein, or calcareous elements, dwindle away, so that the sandstones and conglomerates ultimately form the series from top to bottom. This thinning out of the limestones towards the south, and the preponderance of detrital beds, is a remarkable circumstance, since in conjunction with the apparent absence of the formation in low European latitudes, and its general prevalence in high latitudes even as far north as Spitzbergen, this would indicate that it is essentially a northern deposit. Murchison draws attention to this fact, and remarks that there is evidence of the presence of Permian beds "in the most northern parts of eastern Europe, extending even to the White Sea, and ranging southwards throughout Russia, and on the western flanks of the Ural Mountains, to beyond 50° of north latitude, south of Orenberg. In following this parallel to the west we see that it passes by the northern foot of the Carpathians, and that trending between the Riesengebirge and the Alps, it traverses the smaller German States and the north of France to the south of the British Isles, thus leaving to the north all that portion of Europe in which any Permian rocks are known." In Great Britain this group consists, where clearly developed, of red and yellow sandstones, conglomerates, and breccias below, of marls and magnesian limestones in the middle, and red sands and marls above. Several tracts of red sandstone, which were formerly considered to belong to the lower new red sandstone, the lowest member of the triassic group, really appertains to the far older Permian series. The extent of some of these changes may be gathered from the following observations of Sir R. I. Murchison:—"Professor Harkness and myself have demonstrated the existence in Westmoreland of a range of the Permian rocks of great thickness in the valley of the Eden. There the lowest band consists of the Penrith sandstone, surmounted by calcareous breccias, the middle part of impure limestones and shale, with plants identical with those which lie in the marl-slate beneath the magnesian limestone of Durham, and of massive overlying red sandstones, with gypsum. The latter are of great thickness in their range to Corby Castle, and also at St. Bees' Head, where they overlie a very thin course of magnesian limestone with fossils. To the north of this no magnesian limestone or Zechstein has been seen; and when the Permian rocks range into Scotland they become one vast mass of sandstones, overlying the coal formation. I suggested, indeed, many years ago, that the sandstone of Corncockle Muir, near Dumfries, so celebrated as exhibiting the footprints of the large sauroid and other reptilian animals, illustrated by Sir W. Jardine, would fall into this category . . . . . It is also now ascertained that much of the red rock which overlies the coal of Ayrshire is of Permian age, as well as those red sandstones in the southern part of the Isle of Arran, which Sedgwick and myself classed as new red sandstone, at a period when Permian classification was unknown. Recently, Mr. Geikie has ascertained that subordinate to the lowest zone of the Permian rocks of Ayrshire, there are beds of contemporaneous igneous rock,—a point of exceeding interest in showing that in parts of Britain, as throughout central Germany, volcanic evolutions were frequent in the period of the lower Permian. Professor Harkness and myself have also expressed the opinion that the valuable hæmatite which often occurs at the base of the Permian rocks of Cumberland was formed at the commencement of this era, so marked by the great changes which occurred after the carboniferous era. This observation is of great interest; for it demonstrates that in our own country there exist the same evidences of igneous activity in this epoch, particularly in its earlier part, which are so common in the Roth-liegende or lower Permian of Germany." The same authority is convinced that the Heavitree conglomerate near Exeter; the red rocks of many parts of Shropshire, Staffordshire, and Worcestershire; the sandstones with silicified trees at Allesley, near Coventry; as also those at Kenilworth, belong to this age. The marked contrast in the nature of the Permians of the north-west and of the north-east of England is very remarkable, and is most characteristically displayed by the former being almost wholly detrital, and the latter largely calcareous. In the former district, however, there are some other peculiarities, the consideration of which must detain us for a brief while. The lowest visible portion of the series consists largely of some curious breccias, composed mainly of unaltered fragments of the adjacent carboniferous limestone. Next succeeds a mass of red sandstones, followed by breccias associated with red sandstone. The breccias are formed of fragments of limestone, derived from the carboniferous limestone, but these have all been converted into dolomite. Above these, there are other red sandstones, but of peculiar character, being formed almost entirely of grains of quartz, of unusual size for sandstone, and possessing facets of crystallisation. The particles are angular, or subangular, so as to render the rock a fine-grained breccia. The restriction of these dolomitic breccia to the middle portion of the series is interesting, as showing that the dolomitizing agent was temporary in its operation. At Kirkby Stephen, there is a breccia in the upper Permian series, which is composed of unaltered limestone fragments, so that its formation occurred after the dolomitizing action had ceased. The dolomitizing cause is supposed by Sir R. I. Murchison to be connected in some way with gypsum deposits, and it is suggested that the magnesia of the dolomites originally existed as a sulphate of this earth, from which was derived the sulphuric acid combined with the lime in gypsum. The lower breccias frequently rest upon the eroded surface of the carboniferous limestone, filling up depressions, crevices, and caves, which have been formed in it. In this condition the breccia is locally known as the 'crab-rock,' and is so impregnated and associated with hæmatite as to compel the inference that both were formed by agencies operating at the same time. These breccias, which are displayed in so many localities in the northern portion of west England, do not always consist of limestone fragments. The material varies with the district; thus in Scotland they are mostly formed of fragments of silurian rocks, against hills formed of which they repose; and in Staffordshire and Shropshire they consist largely of the Cambrian and silurian rocks of the Longmynd country. In the latter district the fragments occasionally attain diameters of two or three feet, and are sometimes polished, scratched, and striated. A round pebble is rarely to be found. After noticing that the striæ are clear and sharp, Professor Ramsay thus describes the appearance of the fragments: "In general, the surfaces, including the scratches, are covered by a thin ferruginous crust. The confused and irregular manner in which the whole is bedded, the angularity of all, and the great size of many of the stones, together with the pasty clay in which they lie, present such strong resemblance to much of the drift, that, except for differences in hardness, the appearance may almost be said to be identical. All the places where the breccias occur lie from 25 to 40 miles distant from the presumed parent rocks; and few English geologists now believe that unrounded boulders, sometimes several feet in diameter, and deposits of this kind generally, could have been carried so far, either by ordinary marine currents, or by assumed violent floods. I believe that only the transporting power of floating ice long continued, could have produced results of such magnitude marked by the peculiarities above described. The rock is of the same age as the Roth-todt-liegende of Thuringia, is identical with the coarse angular conglomerates of that formation in general appearance, and I believe they both had the same origin." The characters of these fragments can be well examined in the Museum of Practical Geology.

The life of the period, as presented to us in these rocks, is far more nearly connected with that of the earlier carboniferous, than with the later triassic period. It has a general resemblance with the former, but it is quite different in its character from the latter. One remarkable feature about it is, that most of the species range throughout the greater part of Europe; another, that there is a marked difference between the species in the earlier and in the later beds; a third is, that in all the groups the number of species is surprisingly less than occur in rocks of the period immediately preceding and succeeding the Permian; and a fourth is, that in the case of some groups, the individuals are dwarfed in size.

In the foregoing part of this article we have mentioned an extraordinary conjunction of phenomena, and now we would briefly allude to some of the views which have been offered to account for them. Sir R. I. Murchison dwells much upon the indications of the disturbance of the ground, the frequency of volcanic outbursts, the metamorphism of the limestones, as manifesting that the principal agent was increased volcanicity, which superinduced great earthquakes, dislocations, and floods, whereby the strata were piled up and strewed about in the confused way that we have described. As to the striated stones being proof of glacial action, he says, there is no valid reason. The scratches have been found at one place only, according to him,—a statement which is, however, opposed to evidence,—and may have been marked by other means, such as friction against one another during the convulsive throes to which, he considers, the earth was then subjected. Moreover, the presence of glaciers implies a high mountainous area, and this he opposes as being inconsistent with his belief that the earth was then comparatively flat, and exposed to a warm climate. He rejects the possibility of Wales having afforded such mountains as might be formed by the formation of faults of some thousands of feet throw, mainly because it would be difficult to account for the subsequent removal of the upstanding masses. Jukes was of opinion that the breccia of Staffordshire was derived from a portion of the silurian strata, which, he conjectured, might be found just beneath the Permian rocks at the locality where it occurred. Professor Ramsay's view has already been given, and it appears to us, that if it be not true it affords a better explanation of all the phenomena than any other. In fact, if we are not mistaken, there is a close parallel between the Permian and the post-pliocene periods. In other articles are described how the glacial period was ushered in, and accompanied by elevations and depressions of the land; how the ice accumulated and transported mud and boulders in various ways; and how the disappearance of ice was followed by the prevalence of huge lakes; and how, during the period of greatest cold, the limestones were energetically dissolved, and the hollows filled up with a ferruginous mud. If a similar view were adopted for the Permian deposits, we should refer, to the northern distribution, the accumulation against the flanks of rising grounds, the character of the breccia changing with the nature of the underlying surface rocks of the district in some localities, and in others depending upon the nature of the highest rocks, some forty or fifty miles away, as the indications of a Permian drift. Our facts respecting the boulders are not sufficiently precise to say by which mode of ice transportal they were effected; but the Scotch and north England boulders seem to correspond in their position with the boulders which have been pushed over the land by sheets of ice; while those of Staffordshire and Wales seem to have been carried by valley glaciers from a central mountain tract. The occurrence of the great faults in the silurian strata of Wales would warrant the possibility of high mountains having existed then; and as to the difficulty of accounting for their removal by denudation, it is not so great as admitting the fierce elemental war pictured by Sir Roderick Murchison. If the faults are admitted to be so great as the government surveyors assert, and that the silurian strata formed a continuous connected sheet across Wales, it is manifest that the mass of material has been removed, whether it formed mountains or continued to be low land. The formation of hæmatite is more explicable on the aqueous view than the igneous. The patches and tracts of gypsum, rock salt, sulphate of magnesia, marls, limestones, a fauna and flora which seem to warrant the supposition that they frequented lakes and estuaries, are by no means irreconcilable with the view proposed. The poverty of the species harmonises therewith, and does not involve an actual poverty in the creation of the period; for if the carboniferous rocks are partly marine, partly terrestrial, and partly fresh water deposits, we should expect to have a richer specific development than in the Permian, supposing them to have been mainly formed under the reign of ice, land surface, and vast lakes. The small size of the species probably had no connection with the temperature; and, at any rate, this feature is not a safe criterion of cold, since, in many cases, species are represented by larger species in the cold seas than in those of more southern latitudes. There are, unquestionably, many difficulties to be overcome before such an hypothesis be accepted; but those difficulties appear to be such as may be overcome by putting the idea to a rigorous and thorough test.

Permian beds occur in North America; but as yet, the few exposures that have been discovered are situated in the imperfectly explored regions west of the Mississippi. The carboniferous underlie and pass up so gradually and conformably into the Permian beds, that it is difficult to determine whether there is any definable limit between them. The strata are limestones, marls, shales, gypsum, and indicate the existence of large inland seas or salt lakes. Conglomerates are mentioned; but it does not appear whether there are any signs that could be attributed to glacial action.

(Murchison, *Siluria;* Jukes, J. B., *The South Staffordshire Coal Field (Mems. Geological Survey of Great Britain);* D'Archiac, *Géologie et Paléontologie;* Ramsay and others, *A Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology;* Dana, *Manual of Geology;* Murchison and Harkness, *Q. J. Geol. Soc.* xx., p. 144.)

PLAGIAULAX. A genus of marsupial animals, presenting a remarkable combination of characters. It is represented by about half a dozen fragmentary lower jaw-bones, discovered in the Middle Purbeck beds of Hampshire. These have been assigned to two species, the one named *P. Becklesii,* which was about the size of a squirrel; and the other *P. minor,* which was probably about seven inches in length, exclusive of the tail. There has been considerable discussion as to whether these creatures were herbivorous or carnivorous, Professor Owen maintaining the species were predaceous carnivores, and Dr. Falconer that they were vegetable or insect eaters. As under MARSUPIATA, E. C., a somewhat detailed account has been given of the peculiarities of the jaws of the older marsupials from the Stonesfield slate, a comparison of the present genus with them will not be without interest.

In *P. Becklesii* the lower jaw is remarkable for its shortness combined with great comparative height, the length being two inches and the height one inch. When viewed from the side the characters that most strike the eye are a large, upwardly curved and conical tooth, deeply implanted in the anterior margin; the straight or slightly curved lower border terminating behind in the well rounded articular surface of the condyle; the low position of the condyle, which is far below the grinding surface of the teeth; the deep boldly curved hollow which separates the condyle from the upper point of the coronoid process, whereby the condyle itself appears to be situated at the end of a long neck or process; the great breadth and height of the coronoid process; the peculiar, arc-like outline of the summits of the molar and premolar teeth; the gradation in size and height of the premolars from before backwards; the compressed shape of the premolars combined with the oblique grooves on their crushing surface, which are seven in number in the largest and hindmost premolar; and the small number of teeth, which appear to have been six on each side. In *P. minor,* of which the anterior part only of the lower jaw has been obtained, the front tooth is more horizontal in position; the lower margin of the jaw is more strongly arched, and the diastema or space between the front tooth and the foremost premolar is longer in proportion than in *P. Becklesii.* The principal additional information which this smaller species affords us, is that the true molars had subtuberculate crowns. The name of the genus is derived from the oblique grooving of the premolars.

Such, in brief terms, are the characters which Professor Owen regards as evidences of a carnivorous, and Dr. Falconer of a herbivorous disposition. The characters are unquestionably those of a marsupial mammal; but as the bearing of the evidence on this point has already been discussed under MARSUPIATA, E. C., in treating of the lower jaw of *Thylacotherium,* it would be simply repeating the same arguments if we were to apply the principles there laid down to *Plagiaulax.* The question here is of a more restricted kind; it is not whether *Plagiaulax* belongs to the mammals or the reptiles, but whether it was formed on the carnivorous or herbivorous plan of structure. Owen says the large front tooth was formed to kill, retain, and pierce; that the hinder teeth were adapted to cut and divide soft substances, such as flesh; that the broad high coronoid process indicating a broad temporal muscle combined with the low position of the condyle is a character unknown among herbivorous or mixed-feeding mammals; and that the pedunculate condyle, and its remarkable backward extension beyond the coronoid process is without a parallel in any known carnivorous or herbivorous creature. He compares these peculiarities with their analogues in *Thylacoleo,* a large predaceous carnivore which flourished in Australia during the tertiary period; and in *Hypsiprymnus,* the kangaroo rat, which lives in the same great island at the present time. His conclusion is that *Plagiaulax* was more nearly allied to *Thylacoleo* than to *Hypsiprymnus,* although he points out some striking resemblance between it and the last-mentioned genus. Falconer believed that *Plagiaulax* was far more nearly allied to *Hypsiprymnus* than to *Thylacoleo.* In all the phytophagous genera the solitary incisor in each ramus is placed near the central axis and on the anterior margin, while the outer incisors and canines are absent in most cases, and when present are rudimentary. In all the carnivorous genera there are but three incisors in each ramus, followed by a canine. The position of the single incisor, and the suppression of all the other teeth anterior to the molar series in *Plagiaulax* is in conformity with the herbivorous, not the carnivorous, plan of structure. The canines, which are the special organs for piercing, retaining, and killing, are widely separated, enabling them to grasp with greater security and firmness. The only point in which the foretooth of *Plagiaulax* resembles a canine is its conical form, but its point is slightly bevelled so as to constitute a powerful cutting edge. It does not stand upright as in the powerful tusks of the *Felidæ,* but projects forward with a slight upward inclination as in the wombat [see figure, MARSUPIATA, E. C. vol. iii. col. 715], or the kangaroo rat, both of which are vegetable eaters. It has a still greater resemblance to the incisor of the Aye-aye [see figure, CHEIROMYS, E. C. vol. i. col. 958]. The premolars are the most striking features in the dentition of *Plagiaulax.* In *P. Becklesii* there are three, and in *P. minor* four teeth of this kind, which diminish rapidly in size from behind to before. The hindmost tooth is the best developed and characterised, and agrees closely in form and construction with the corresponding tooth of *Hypsiprymnus.* On this point Falconer says:—"The resemblance is so manifest and direct that I never contemplated that it could be called in question; but as it has been questioned, it is necessary to descend to particulars. In both, the crown viewed from the side is of a gradually oblong form, the length exceeding the height; in both it is compressed and trenchant, the side sloping uniformly from the base to a thin edge like a wedge; in both, the basal part of the tooth presents a smooth surface above which the crown is traversed by a series of close-set, uniform, and exquisitely defined parallel grooves, sharply angular, and bounded by linear ridges; in both, these grooves occupy both sides of the tooth; and in both the channelled sides terminate in finely serrated edges. Not the least remarkable point in this striking list of agreements is the curious numerical coincidence—these grooves being developed, seven in number, alike in the homologous premolars of *P. Becklesii* and of *Hypsiprymnus Gaimardi.*" There are differences, but they are of trivial importance. Thus *Plagiaulax* has three or four such teeth, but *Hypsiprymnus* has only one. In *Plagiaulax* the grooves are oblique, but in *Hypsiprymnus* vertical. Notwithstanding the peculiar form of these teeth, they do not appear to be essentially connected with flesh cutting, but what their functions may be is unascertained; although it may be conjectured to be the same in *Plagiaulax* and *Hypsiprymnus.* An examination of the habits of the kangaroo rat would probably enable us to form some definite opinion on the point. They are nocturnal animals, and feed upon the roots which they dig up with their long toes, so that in this case the grooved tooth has no relation to any carnivorous propensity.

The shortness and depth of the lower jaw is not always an indication of the carnivorous type, since it is found in the Aye-aye and in *Phascolaretus Koala.* The broad high coronoid process is not confined to the carnivores, since it also is to be found in the Aye-aye. The low position of the condyle, and its long horizontal neck is met with in the Aye-aye, but the form of the condyle itself is widely different from anything met with in the carnivores. It is convex, narrow, ovate, with the broad end uppermost in *Plagiaulax,* while in the carnivora it is more or less cylindrical, and transversely disposed, and is so locked into the glenoid cavity of the upper jaw that the lower jaw can only move in a vertical direction. The form of the condyle in *Plagiaulax* has considerable resemblance to those of the condyles in the Aye-aye, the Norway rat, the American marmot, and other rodents. The depressed position of the condyle below the level of the grinding teeth has its counterpart in the Aye-aye. In no predaceous species does the condyle project so far behind the coronoid process as in the Aye-aye and the *Plagiaulax*. These resemblances and differences between *Plagiaulax* and Aye-aye are such as to indicate some common habit in forms which are zoologically wide apart.

(Falconer, *Quar. Jour. Geol., Soc.* vol. xviii. pp. 348—369.)

POST-PLIOCENE PERIOD. It embraces the time immediately antecedent to the present condition of things, and is the link connecting the age of civilization with those periods in which sediments were deposited containing no trace whatever, either of man or of his works. It is a period of especial interest inasmuch as it was that in which the first undoubted signs of man's existence have as yet been found. It was a time, probably, of vast duration, since there are abundant evidences of great changes having occurred in the climate, the configuration of the land, as well as in the fauna and flora throughout the whole of Europe, Asia, America, Australia, and probably every part of the globe. In the course of this article, facts will be stated which appear to warrant the inference that the greater part of Europe underwent a series of up and down movements through a vertical swing of hundreds, and perhaps even thousands of feet; that it was covered to a greater or less extent with enormous sheets of ice and snow, while the climate of what is now the temperate zone was as rigorous as a Siberian or a Greenland winter at the present day; that since its commencement many large river-valleys have been entirely formed; and that large lakes and seas, more especially the great Mediterranean freshwater sea, which then occupied the site extending from the low lands of Hungary on the west, to the Sea of Aral on the east, have been greatly modified or wholly obliterated. These changes would seem to have been produced by the same forces and agents as those which are now in daily operation, some of which were probably developed on a larger scale than at present. Thanks to busy workers over half the world, we shall be able to show, though, perhaps, not so clearly as might be desired, that these changes followed one another in a definite order throughout wide-spread areas, and that each phase is represented by strata having well-marked distinctive characters.

The post-pliocene group of strata, according to Sir C. Lyell's views, embraces those whose palæontological evidence indicates, that during the time of their deposition, all the *Mollusca* which lived then are still in existence, and that these were associated with extinct species of *Mammalia*. The post-pliocene age of the unfossiliferous strata is deduced from their stratigraphical position relatively to those which are fossiliferous. The post-pliocene period of time, then, extends from the date when the last extinct species of mollusk died out to that when the last extinct mammalian disappeared from the living fauna. As will be seen, the definition is an arbitrary one, and, strictly speaking, we are practically unable to fix the limits with precision. Moreover, it must be borne in mind, that this period is not a mere isolated link in geological time, being more or less intimately blended with that which preceded it, viz., the pliocene, and with that which has succeeded it, viz., the recent. Notwithstanding these defects the above definition of the term post-pliocene will be that adopted in this article; misapplications of the term will occasionally happen, but these are frequently unavoidable in the present state of our knowledge. For example, to give a few instances,—a bed may have been deposited during the latest part of the post-pliocene period, and yet contain only recent species of shells, owing to the fact, that none of the extinct species then living happened to be preserved in that particular bed. Again, beds deposited long after the close of the post-pliocene period, may contain an assemblage of species having as well-marked a northern or even Arctic aspect as those characterizing the older post-pliocene beds. Indeed, there are not a few spots in the deepest water off Scotland where the dredge brings up scarcely anything but characteristic northern species, which seem to have lived on to the present time, and to be the few remaining relics of a condition of things long since passed away. And yet again, it may happen that beds with recent organisms only are really of post-pliocene age, since the post-pliocene fauna lingered on in some areas long after it had become extinct in others.

As the post-pliocene strata are well developed in Scotland, and have been carefully studied, an account of them will first be given in order to indicate the succession of events, and to have some convenient standard with which the strata of other parts of Great Britain can be compared. Jamieson and others have inferred from the phenomena presented by these strata, that they bear witness to a series of periods which Professor Jamieson has named, (1.) that of land ice; (2.) that of depression; (3.) that when the land emerged, and the glaciers retreated; (4.) that of the second depression; and (5.) that of the re-elevation of the land to its present position. The last two periods probably belong to the recent era.

The period of land ice is indicated by the general occurrence of striations on all the hard rocks of the country which have been sufficiently well protected to preserve any markings they may formerly have received. These scratches and groovings occur in numerous localities from the south of Scotland to the northernmost islands, and from the highest elevations to unascertained depths below the lowest water mark. When all these markings are mapped, a general system of arrangement is at once recognized. The direction of the striations in most cases corresponds with that of the main slopes from the principal water-partings of the country; where there are exceptions, the deviation appears to be due to the slope of some of the larger valleys. The direction of the striations is uniform over such large areas that one is led to believe that the striating agent flowed or moved outwards from the west as one continuous sheet, and not in a series of narrow lines coincident with the valleys. This view is further supported by the facts seen at Shehallion and Morven, which are high hills occurring as detached isolated eminences at some distance eastward and southward from the main water-parting crest. Shehallion is marked with striations along its flanks and near its summit, and their direction shows that the striating agent moved, not from the top of the hill to its base, nor horizontally round its flank, but that it impinged against its northern sides and pressed right over it. Morven has granite boulders on its summits which appear to have been derived from some of the mountains in the main water-parting crest. Under BOULDERS, E. C. S., facts are cited, indicating that the agent which transported some of them was a broad mass which flowed from the highest mountain range towards the sea shore. All these phenomena are best explained by the hypothesis that the land was covered with a sheet of ice some thousands of feet thick, which moved outwards from the higher land. The modern example which most resembles this state of things is the great mountain range of Greenland. The only difficulty that presents itself to this explanation is the intensely cold climate which it requires; but as there are many other facts afforded by widely different branches of inquiry, which corroborate the contemporaneity of a cold climate with the time when these striations may have been formed, this difficulty may be an imaginary one only. On the other hand, the hypotheses of valley-glaciers, or of submergence, not only do not suit the facts already mentioned, but they are not in accordance with those derived from other sources. Upon these old ice-worn rocks there is a mass of mud, crowded with hard angular fragments of all shapes and of all sizes below 10 or 20 feet in length. The fragments present no trace of stratification; their surfaces are covered with striations, and the direction of these striations frequently correspond with that of the striations on the rock immediately underlying them. If the higher country towards which these striations point be examined, the rocks will generally be found to be identical in character and composition with those of the transported fragments. This, again, shows the direction in which the transporting and scratching agent moved. The mud is just such as would be formed from the trituration of the underlying strata. It is called *boulder-mud* by some, *boulder-clay* by others, *true bolder-clay* by others; and by yet others it is termed *till*. There are, however, accumulations in other countries which are also called by these names, although it is probable their origin and period of formation were widely different. We shall, therefore, call the formation under notice the boulder-clay of Scotland. Its character is very peculiar. It is an intimate mixture of a fine impalpable mud and stony fragments; it is generally exceedingly tough and compact, as though it had been puddled under some enormous weight; it is so unworkable, that the hammer is useless, and even contractors find that neither blasting nor digging will remove it, and that the only serviceable instrument is the pickaxe. Its removal is said to be more costly and tedious than that of the same mass of trap or granite. The absence of all fossils, except such as have been derived from older beds, is also a well marked feature of this clay. The absence of stratification and fossils negatives the idea of its being a marine deposit; the non-separation of the finer from the coarser particles is an objection to its having been dropped from floating ice into comparatively still water, as also is the sheet-like distribution of the clay, and the derivation of its stones from broad zones of local rocks. These things rather indicate great friction under enormous pressure in the presence of moisture, or precisely those conditions which now exist at the lower surface of the great ice-cap of Greenland. The melting of the under surface there proceeds during the coldest weather. Further information respecting continental glaciers or ice-caps will be found under GLACIERS, E. C. S. The inference to be drawn from these details is, that Scotland was during this period above the sea, and not below it; and that, probably, the land was not only absolutely higher than it is now, but was also more elevated out of the sea.

The period of depression is represented by a series of strata, which Jamieson calls the glacial marine beds. They rest upon the boulder clay, the surface of which is irregular and undulating, in consequence, partly of original conformation and partly of slight denudation subsequent to its deposition and prior to that of the marine beds. In the lower ground the overlying stratum is a laminated clay, which sometimes fills up hollows in the boulder clay, and sometimes covers it in wide sheets up to about 300 feet above the sea. At this and greater altitudes, up to 500 or 600 feet, sands and gravels are interstratified with, or replace, it. This clay is of a light character, generally laminated, and contains numerous marine shells, many of which have both valves together. Stones and boulders are far less abundant in this clay than in the older boulder clay; the striations on the pebbles are frequently almost, or entirely, obliterated either by rolling or weathering, and those which do occur are not so deep and strongly incised as those on the stones from the older clay. The boulders occur under circumstances which imply they have been dropped from floating ice, and all traces of a great grinding agent, spreading outwards from long axial lines, are wanting. The presence of the marine shells, the stratification of the deposits, the character and mode of disposition of the stones and boulders, all point to a partial submergence of the land. The amount of depression was, at least, sufficient to bring all the land, which is now below the altitude of 512 feet above the sea (the greatest elevation at which marine fossils have been found), down to the level of the sea. During this period the ice-cap was confined to the higher ranges, and the ice moved outwards down the valleys, and not along the main slopes of the country. The line of perpetual snow was probably some hundreds of feet above the then sea level. Jamieson believes that some of the valley glaciers of the period extended into the sea, because these marine beds are absent from some of the largest valleys, such as the valley of the Forth, while the lower portions of them are filled with heaps of unstratified gravel and stone debris resembling glacier moraines. The Loch of Monteith is believed to have been formed by the damming up of the waters by a moraine stretching across the valley of the Forth. The surface of the lake is now 55 feet above the present sea level, and, as it is very deep, its bottom is probably below the sea level. The site of this lake has been apparently so pre-occupied, or protected, that no marine beds were deposited on it during the period of submergence. A glacier extending into the sea would account for this as well as for the moraine-like heaps.

The next period, or that during which the land again rose, and the glaciers gradually disappeared, is represented by the formation of certain valleys, the occurrence of gravel on their flanks, the existence of moraines at considerable elevations above the sea, and of old peat beds with embedded trunks of trees, indicating the sites where former forests grew. The gravels, moraines, and glacial traces, are frequently so associated in the same valley as to indicate a definite succession of events. The moraines occur in most of the mountain glens, and merge in the downward direction into the valley gravels, which frequently extend as far as the sea. The study of these valley gravels is rendered somewhat difficult by the circumstance, that in many cases they have been more or less acted upon by marine action since their original deposition. The denudation that preceded the formation of the gravels resulted in the excavation, wholly or partially, of many of the river valleys; and this denudation took place subsequent to the deposition of the laminated clay. The apparent concurrence of the retreat of the glaciers with the excavation of valleys and the formation of valley gravels is what might be expected from an elevation in the temperature of the climate. It is paralleled by those Arctic countries where the snow of winter is rapidly melted during the warm season, and floods and freshets are of frequent occurrence. Subsequent to these gravels forests made their appearance on the low lands on most parts of the coast, more especially in the estuaries. The peat beds which they have left are generally continuous below the present sea level, showing that, at the time of their growth, the land was somewhat higher than it is now. The stumps of trees remain upright surrounded by the leaves, branches, and seeds of plants. The prevailing trees are the birch, the hazel, and the alder. This peat bed may be seen in the Friths of Tay and Forth wherever the old estuarine clay has been removed.

The period of second depression is represented by the estuarine clay and raised beaches fringing the shores of Scotland. This clay is a fine sedimentary silt remarkably free from stones, and forms the subsoil of most of the Carse lands, whence it is frequently called the Carse-clay. It extends up the valleys to 30 feet and less above the level of the sea, indicating the upward limit of the depression. This limit is not horizontal, for it is known to decrease gradually from 30 feet above the sea in the Frith of Forth to less than 8 feet at Aberdeen. The fossils found in this clay indicate that it belongs to the recent period, so that the post-pliocene period terminated before its deposition. The characteristic shell is *Scrobicularia piperata*.

The beds of peat and blown sand which overlie the old estuarine clay bear witness to the re-elevation of the land. This event took place long after the first appearance of man in Scotland, and probably before the Roman invasion, although some authors contend that it happened after the appearance of the Romans in that country.

So far then as Scotland is concerned, we have evidence not only that the land has been elevated and depressed, but also that there is apparently a marked gradation in the extent of the vertical movement. Restricting our attention to the strata already noticed, the relative position of the land during each period may be thus roughly indicated:—

First Period.—Land at its highest; probably hundreds of feet higher than now.
Second Period.—Period of greatest depression; land probably hundreds of feet lower than now.
Third Period.—Land not so high as during the first period; but still higher than it is now.
Fourth Period.—Time of second depression when the land was less than 100 feet lower than now.
Fifth Period.—Land at its present elevation.

In the Lancashire and Cheshire district the same general sequence of events appears to have occurred as in Scotland; but, owing probably to the somewhat different conditions under which the strata were deposited, it is difficult to correlate the beds of this area with those of Scotland. And the difficulty is much increased by the rather indiscriminate application of the terms till, boulder clay, and drift to these beds. Without pretending to be able to use these terms properly ourselves, we shall, nevertheless, endeavour to call strata of a similar nature or age by similar names.

The traces of the period corresponding with Jamieson's first period have not yet been found in any abundance in the area under notice. Striæ, groovings, and a peculiar hummocky condition of the harder rocks, have been found on the higher elevations of the Pennine chain, the Cumberland mountains, &c.; but the facts are too few and disconnected to warrant the inference, that they were formed either by continental or valley glaciers. The apparent absence of the general glaciation of the surface, whereby the rocks were ground down in broad bands, as also of any clay which corresponds closely in texture, and mode of occurrence, with the boulder clay of Scotland, gives the impression that the ice-capping, in this part of the country, was far inferior to that of Scotland during the same period. There are, it is true, striated surfaces at all elevations below 1400 or 1500 feet; but in most instances these striations appear to have been done by packed or shore ice, and may therefore belong to a subsequent period.

The second period, or that of greatest depression, is more abundantly illustrated; indeed, the great proportion of the Lancashire and Cheshire post-pliocene strata may probably be assigned to this stage. These strata are so variable that as yet no generalization can be made without risk of error. They consist of a series of gravels, sands, and clays, generally more or less stratified, and frequently fossiliferous. The lowest bed in many places is a gravel or sand. Near Stockport it underlies a very stiff, dark-coloured boulder-containing clay; it is stratified, composed of rounded grains, and contains numerous fragments of marine shells, of which the majority appertained to *Cardium edule* and *Turritella terebra*. A sand occupying a similar position has been met with in most of the well-borings in and about Manchester. At Macclesfield coarse sands and gravels underlie boulder-bearing clays, and rest upon the solid rock. Here the stratification is mainly horizontal, although frequent examples occur of false bedding and other evidences of changes in the direction of the currents. These beds also abound in fragments of shell, of which *Turritella* and *Cardium* are the most abundant. *Fusus Banfius*, *Tellina*, *Nassa*, and others, are associated with them. Some of the shells have been met with 600 feet above the level of the sea. At Rainford, near Liverpool, a gravelly clay and sand are the lowest beds; and contain *Turritella terebra*, *Fusus Banfius*, *Nassa reticulata*, *Cardium edule*, *Tellina solidula*, and *Tellina tenuis*. Round Liverpool a similar stratum occurs, which is sometimes called lower drift sand. It may be seen in most of the cliff sections along the banks of the Mersey, and here also it contains marine shells, such as *Turritella communis*, *Nassa reticulata*, *Nucula oblonga*, *Natica*, *Patella*, *Tellina*, &c. In the higher lands towards the north, as at Burnley, this set of beds appears to be absent, or at any rate, comparatively rare. In their lithological character these lower sands and gravels are hardly to be distinguished from those which occur at higher horizons. They apparently extend from the sea shore up to 1300 and 1400 feet above the sea. At the higher localities, however, there are no overlying clays, and as the lower sands and gravels have not been followed up continuously some writers dispute the identity of the beds at the higher and lower levels. Where these gravels contain the largest quantity of shells they have all the appearance of a shelly beach; and, indeed, these gravels may be regarded as a more or less continuous raised beach. An interesting example of an old raised beach occurs near the summits of Grin Edge and Harper Hill, a little south of Buxton. It is estimated to be 1435 feet above the present sea level. Fuller details respecting it are given under RAISED BEACHES, E. C. S. Above the gravels in many parts is a boulder-containing clay, called boulder clay and till by the local geologists. Its character varies in different districts. It is rarely a single bed of clay, but is frequently inter-stratified with beds of gravel and sand, which are sometimes fossiliferous and sometimes barren. In the lower districts it is generally free from arenaceous or gravelly partings, but these become more frequent and more bulky as the higher ground is approached. The description by various authors seems to indicate a connection between the colour of the clay and the underlying or contiguous rocks. Thus, at Liverpool, where is a broad band of new red sandstone, the clay is a dark red clay, containing numerous pebbles and boulders, varying in size from peas to masses six feet in diameter, many of which are striated. They consist of quartz, granite, syenite, porphyry, greenstone, basalt, limestone, and new red sandstone. *Turitella communis*, and *Mactra truncata*, are of frequent occurrence. About Manchester, which is situated amidst the coal measures and the red sandstones which overlie them, the clay is stiff in texture and brown in colour. It contains fragments of the same kind of rocks as are met with in the clay at Liverpool of all sizes, varying from small pebbles to blocks six tons in weight. Most of the fragments from a distance are more or less rounded, while those from less distant rocks, such as millstone grit, are frequently angular. Most of the specimens are striated. In the neighbourhood of Burnley the clay is blue, the colour being due probably to the slates of Cumberland. The strata hereabouts have a closer resemblance than any others of the same group farther south and west to the boulder-clay series of Scotland. Thus, at Swindon, near Burnley, the lower bed is a hard compact blue clay; while above it lies a similar blue clay, which is variously described as being soft or sandy. In places sands and gravels occur between the two blue clays; and in others sands with thin seams of clay. These last are frequently laminated. These inter-stratifications of gravel and sands with the clay have given rise to considerable differences of opinion amongst the local geologists, for while some contend there is but one "boulder clay," others assert there are six or more. Truth and error seem to be equally divided between all parties, for while along the sea shore there is but one boulder-containing clay; in the higher ground this becomes split up into several bands separated by beds of sand and gravel. The wedge-shaped commencements of these intercalated layers have frequently been met with, and in most instances, probably all, the sharp edge of the wedge points away from the high ground, or towards the south and west. Above this argillaceous series lies an upper sand and gravel formed of rounded fragments of the same kind of rocks as are most common in the lower gravels and sands. According to Mr. Binney, it forms the gently rising slopes of Lancashire and Cheshire. It varies much both in composition and thickness. Near the sea at Ormskirk the "till" or boulder-containing clay is sometimes found without it, but in proceeding east it makes its appearance, and gradually thickens until it attains its greatest thickness, near the base of the Pennine chain. The country lying between Manchester, Bolton, Bury, Rochdale, Ashton, and Stockport, is mostly situated upon it. The gravels about Crewe belong to this series; as also what is sometimes called the upper drift sand near Liverpool. The great dissimilarity between these beds and the boulder clay of Scotland is well marked; the occurrence of shells from the lowest to the highest strata; the abundant evidence of the sorting action of currents of water afforded by the stratified, false bedded, and laminated clays and sands, evidence which is moreover confirmed by the usual position of the long diameters of the pebbles, which are generally inclined toward the south-west. True it is, there are hard clays well packed with angular and transported fragments, which are highly polished and scratched, but these clays also contain other fragments, which are more or less rounded. The facts are not such as might be looked for as signs of a highly elevated glaciated land; but they appear to be the indications of a submerged area in close proximity to a land which does yield glaciers. Most of the foreign boulders come from Cumberland and Scotland. On the whole, then, we are inclined to believe the beds just noticed indicate the period of great depression in this part of England, a period which was probably contemporaneous with the same period in Scotland; and therefore we should synchronize the so-called boulder clay or glacial drift formation of Lancashire and Cheshire, with the glacial marine beds of Scotland. The amount of depression appears to have been 1400 or 1500 feet.

In the period which followed the deposition of the beds just noticed we have proofs of the excavation of river valleys, the accumulation of valley gravels, and the growth of forests which are now partially submerged. The same events occurred in Scotland, but in Lancashire and Cheshire no signs have yet been discovered of moraines, whereby a clue would be given as to the height of the land relatively to what it was prior to the great depression. The position of the submarine forests shows it was higher then than now; but there is nothing to show whether it was less high than during the first period. The usual order in which the events took place was thus;—the excavation of the valleys; the accumulation of valley gravels; and the growth of forests. The valley of the Irwell is excavated in the boulder-containing clays, and the hills which bound it are capped in places, as at Pendleton and Kersall Moor, by the upper sands and gravels; the excavation must therefore have taken place since those sands and gravels were laid down. In the hollow thus formed the lowest bed is generally a gravel, arranged in two well marked terraces, at heights of about 40 and 86 feet above the present level of the Irwell. Upon a valley gravel, in one of the valleys, the stools of large trees have been found in one or two localities, with their roots growing into the gravel itself. At Liverpool, and all along the contiguous shores, submarine forests are of frequent occurrence. Thus, one was found 35 feet below high water level, beneath the north docks; and again 40 feet below the same level at the Custom House. Other instances could be recorded to show that the land was higher when these forests grew than it is now by about 50 feet. Above these old forest beds are a series of blue silts, loams, and peats, which are marine in the lower grounds, probably estuarine higher up, and fluviatile at still higher elevations. There are one or two forest beds inter-stratified with them, and the highest of them, such as that 3 feet below high water mark at Leasowes, and those just below the same level at Dove Point and Formby are known to have been submerged during the historical period. Above all we find mounds of blown sand. These beds correspond with the third and fourth periods of Jamieson; during the third period the latter was somewhat higher than now; and during the fourth it was depressed less than 100 feet. The depression about the mouth of the Mersey in recent times appears to be a local peculiarity, and distinct from the general depression indicated by the older forest beds. The fifth period, or that of re-elevation to the present level, is rendered obscure by this local depression, but there are evidences of it in the terraces of valley gravel, and in raised beaches along the rocky shores of North Wales. The old forest bed near Liverpool appears to be the latest of the post-pliocene period, all above being recent. Flint implements and bones of the *Equus fossilis* have been found in the valley gravels.

It would render this article disproportionately long were we to treat all the districts where post-pliocene strata occur in the same detail as the foregoing, and want of time will not permit us carefully to examine and classify the numerous notices scattered through the scientific periodicals. We believe, however, that such an inquiry would show that in Wales and central England the same succession of elevations and depressions occurred as in Lancashire and Scotland. The period of great glaciation, of the existence of which no good evidence has been yielded by Lancashire and Cheshire, appears to have left its marks on the lofty highlands of Wales. We come again upon what probably corresponds with the true boulder-clay of Scotland. It is met with at the heads of all the principal river valleys, and the valleys of the present rivers at those points are excavated in the clay; it is unstratified, unfossiliferous, and presents no signs of having been deposited by a sea. It is so situated on the higher eminences, and at such heights, as to render it very unlikely that they have been placed where they are by rivers, rains, floods, or any kind of water action. And yet the boulders in it are all local, and, according to Symonds, "have been carried across particular districts and down particular hills." The peculiar association of phenomena here referred to, the absence of some, and the presence of others, seem to point to a time when great continental glaciers passed over the land down the principal slopes, undisturbed by the minor inequalities which have in many cases been produced since they ground down the strata and spread the boulder mud over the slopes of the higher hills.

The period of great submergence in Wales is represented by the boulder-containing clays, sands, and gravels, in which have been found marine shells. The newer clay is quite unlike the older boulder-clay; it occurs at lower elevations, its highest limit being about 2000 feet. The boulders in it are partly of local origin, and partly of foreign; some of them are angular, but many are more or less rounded, a feature which is very common in the so-called boulder-clays of the Lancashire district. These beds indicate a time when Wales was submerged up to 2000 feet, beneath the sea. The 'drift' of Moel Tryfaen belongs to this period, and is not, as its name would imply, a collection of materials transported bodily or in masses from some distant region, but it consists of a series of sands and gravels about thirty-five feet thick, which present that irregularity of disposition, rapid alternation of coarse with fine materials, and abundance of shelly fragments, so common in the shore deposits of the present time. The molluscan fauna, comprising nearly sixty species, has the same character as that of the Macclesfield drift, and both appear to belong to the period of depression. The sand and gravels of the high plains round Birmingham and Warwick, which most authors call drift, as also the drift at Strethill and other places in the valley of the Severn, were apparently deposited during the same geological phase as the foregoing.

The period of valley glaciers has been admirably treated by Professor Ramsay, in his account of the glaciers of North Wales and Switzerland. All the valleys radiating from Snowdonia are grooved, scored, and worn into hummocky surfaces up to 800 or 900 feet above their floors; perched blocks and lines of striated fragments mark the positions of the lateral moraines; and heaps of irregular debris of scratched angular fragments mark the spots where the glaciers terminated. Subsequent to this grooving, scratching, and transportation of blocks down valleys, numerous facts show there was a time when water accumulated in large quantities, filling the lakes, rushing down the lower valleys so as to do the work of excavation, and forming the valley gravels. The earlier portion of this time was probably contemporaneous with the minor depression of the country when North Wales was submerged up to a height of about 400 feet above the present sea level. It was during this period of submergence and re-emergence that the raised beaches along the northern borders of Wales were formed, as, for example, those at Llandudno, the Little and Great Orme's Head, and many others. During this period, also, the Vale of Clwyd was a wide estuary stretching for many miles as a winding fiord into the interior of the country. The action of the waves of this estuary scooped out the numerous caves in the limestone cliffs which now bound this picturesque vale. At Llandudno a continuous sea-beach may be traced from high water mark up to nearly 300 feet above it; at this height the flank of the limestone mountain is marked by a line of rounded projections and recesses, and at one place by a series of caverns. In one of these caves Miss Eyton found a shingle identical in character with that now forming on the beach below. The shells found in the raised beach are the same as those which are common on the present beach, but they are intermingled with land shells. Round the shores of Wales are also to be met with, beds of silty clay, peat, submerged forests, and blown sand, similar in character to those on the shores of Cheshire and Lancashire.

The vertical movements in North Wales, like those of Scotland, remind one of a series of vast undulations gradually dying out; but the evidence seems to indicate that the movements in North Wales were more extensive than in Scotland. Advancing southwards along the coast, the next point we stop at is Porlock Bay, on the south shore of the Bristol Channel. The superficial deposits here have been described by Godwin-Austen, who finds the order of the beds to be as follows, beginning with the highest bed: (1) shingle bank; (2) marine silt; (3) surface of plant growth; (4) fresh water mud deposit; (5) forest growth; and (6) angular detritus. The angular detritus rests upon the strata belonging to the Devonian series, and is clearly derived from them. It occurs on all the high ground surrounding the bay, and frequently long streams of it can be traced as though it had been brought from the higher to the lower levels by a glissade-like motion. Sometimes it is accumulated in thick masses at the mouths of deep glens. At others it contains an intermixture of water-worn pebbles which mark the sites of former torrents. Its peculiar features are believed to be due to the action of frost, snow, and other atmospheric agencies upon a land which remained for a long time above the sea. Upon this detritus lies the forest bed; it was evidently the surface on which the trees grew, since wherever the stools are upright they are seen to be rooted in it. Surrounding and overlying the remains of the old forest is a blue silt, which Godwin-Austen is inclined to believe is of fresh water origin, from the abundance of vegetable matter diffused through it, and the absence of any organic remains. The roots of the trees were never found to penetrate into this clay. On the surface of this clay is a dark band formed of a mass of matted vegetable debris, from which roots can be traced into the clay; this shows that it was the surface on which the plants grew. Upon this surface rest the trunks of the trees, whose stools still remain rooted in the underlying angular detritus. The trunks were in some instances more than twenty feet in length, and in no case were they observed to have sunk below the surface of the old plant growth. The trunks are embedded in the next overlying bed, which is a yellowish-brown sand, containing numerous perfect valves of *Scrobicularia piperata*. And latest of all comes the shingle beach. The layer of angular detritus was formed when the land was higher than at any subsequent period, and we should therefore assign its age to Jamieson's third period, or that when the land of Scotland, Cumberland, and Wales re-emerged after the great depression; but the absence of any indications of glaciers or of glacial marine beds renders it possible that the angular detritus represents the first three periods of Jamieson's table. Godwin-Austen adopts the latter alternative, and from this and other evidence infers that the West of England was above the sea during the whole of the glacial period. In corroboration of this he alludes to the immense masses of fluviatile deposits around the Bristol Channel, which are so large relatively to those formed by other English rivers of similar size, that he regards them as the accumulated glacial alluvia of all the rivers of the west, from the Severn to the Tone; and the equivalents in age of the great accumulations of angular debris. The patches of clay-with-angular-flints, which occur so abundantly over the North Downs, appear to correspond with the angular detritus, and to have been formed by the same agencies during the same period. Over the larger portion of these Downs no marine beds of post-pliocene age have as yet been detected, a fact which, if established, would indicate that they have been above the sea while Scotland and Wales have been twice beneath it up to elevations exceeding the height of the Downs. In connection with this we may here allude to the gravels of the south-east of England, which, like those of the west referred to by Godwin-Austen, appear to have been gradually accumulating throughout the glacial period. The forest bed of Porlock Bay occurs under such circumstances as to imply a depression of about 120 feet since their growth, so that when the old forest flourished the land was upwards of one hundred feet higher than at present. The trees did not begin to grow till after the detritus had been accumulated, and probably not until the snowfields had passed away, which was probably somewhat before the termination of glacial conditions in Wales and Scotland. And if the angular detritus be contemporaneous with the fluviatile gravels of the West of England, the forest is posterior to the excavations of most of the river valleys. In short, it grew during the same geological, or climatal, phase as the older forest whose remains underlie the estuarine clays of the Tay and the Tweed. The Porlock forest may perhaps have grown at the same time as the submerged forests along the coast of Wales, as in Cardigan, St. Bride's, and Swansea bays, as well as those already alluded to along the shores of Lancashire and Cheshire. The beds 4 and 3, overlying the Porlock forest bed, are local, and have no recognised representatives in the districts already noticed. Godwin-Austen regards them as proofs of a depression and re-elevation, but we would rather assign them to a lake which was rapidly filled up. The time occupied could not have been long, since both were formed during the lifetime of a tree, and the trunks were enveloped in a marine silt before they had decayed. The Scrobicularian sand answers to the yellow clay all along the low shores of the West of England, and corresponds with the coarse clay with *Scrobicularia* of Scotland. The trees were probably killed by being immersed in the sea. The area about the Bristol Channel is considered to be near the southern limit to which the great vertical movements of the glacial period extended. From North Wales, where the land sank 2000 feet or more, the amount of depression gradually declined towards the south, until at Porlock Bay it did not exceed one hundred and twenty feet.

On the southern side of the same promontory occur gravels, boulders, and other phenomena which corroborate the inferences drawn from what is seen in and around Porlock Bay, and at the same time indicate that the same peculiar subaerial conditions also prevailed there. In the upper part of the basin of the Teign, where the land is from 400 to 1500 feet above the sea level, are numerous boulders of granite and carboniferous strata which have been mainly derived from spots a few miles from where they now lie. They occur chiefly on the tops of the highest elevations and on the upper part of their flanks. At the junction of the North and South Teign rivers is a hill, the face of which looks up the stream. On this slope large blocks of granite are piled on one another. One of them, the Puckie Stone, is 26 feet long, 8 feet 8 inches wide, and from 8 to 10 feet high; and its angles are more or less rounded. With the exception of signs such as these, there are no indications of anything like glaciers. The remarkable way in which the blocks are distributed, their local origin, the frequent rounding of their angles, are best explained on the hypothesis that the winter's accumulation of snow was only partially pressed into ice, and that during the heats of summer the general dissolution resulted in torrents which carried block-bearing ice-rafts a short distance down the valley. Over the highlands are also found extensive areas of gravel, mostly angular, but containing a few rolled fragments. This kind of gravel is not met with in the lower parts of the valleys, and appears to have been formed prior to and during their excavation. It is the "Old Gravel" of Ormerod ("Quar. Jour. Geol. Soc.," xxiii. p. 418), and doubtless corresponds with the angular detritus of Godwin-Austen. There are no traces of any part of this district having been submerged during the post-pliocene period; although there are one or two facts which possibly point to recent vertical movements of the land. Thus near Sandgate, 750 feet above the sea, is a fine gravel arranged in laminæ resting on granite. The laminæ dip at an angle of about 5° N.N.W., thereby showing, says Mr. Ormerod (l. c. p. 424), the direction in which the granite has been elevated since the deposition of the gravel.

Along the south coast of Devonshire, Pengelley has pointed out numerous proofs of recent change in the level of the land. First there was a depression whereby the country was rendered 280 feet lower than now; this was followed by an intermittent re-elevation carrying the level to not less than 40 feet above what it is now; another depression succeeded, resulting in the present relative position of sea and land. We have a difficulty in correlating these movements with those already noticed. The last period of depression answers to that by which the Porlock Bay forest was destroyed; the previous period of elevation corresponds to that during which the Porlock Bay forest flourished, and *Betúla nana* and willows grew on the plains of Bovey Tracey. The few plant remains as yet found indicate a highly Arctic climate, and so far this is in harmony with Godwin-Austen's opinion that the angular detritus represents the larger portion of the glacial period. The great submergence of Devonshire is undoubtedly older than the angular detritus, and if Godwin-Austen is right the downward movement was pre-glacial. But it is not improbable that a careful inquiry may prove that the great depression of Devonshire was contemporaneous with the period of the glacial marine clays so well developed farther north.

Along the south coast there are frequent occurrences of raised beaches and submerged forests, the latter being covered up by marine silts and peat beds. These appear to be relics of the third and fourth periods of Jamieson; but so far as we have been able to ascertain, there are no signs of any extensive elevation of the country, nor of its great depression beneath a sea. If there is anything to represent these periods it is the great sheets of fluviatile gravel, and perhaps the numerous ossiferous caves.

Along the east coast from Clacton to Flamborough Head there are a series of beds of especial interest, inasmuch as they present some important links connecting the boulder-clay with the pliocene strata. It is along this part of the coast, and apparently along it only, that we can examine strata of an age immediately antecedent to the boulder-clay. They are well shown in the neighbourhoods of Cromer and Mundesley. Lowermost of all, and resting on the chalk, is a forest bed consisting of the stumps of an old forest in which the Scotch fir, the spruce, the yew, and the oak were the most abundant trees. The stumps are levelled off in the same way as those in the forests at Porlock Bay and elsewhere, and are covered by a series of laminated clays, whose organic contents indicate an alternation of estuarine, marshy, and marine conditions. These and other facts are generally believed to indicate an elevation and depression of earlier date than any of those to which we have yet alluded. The organisms which then flourished, the accumulation of lacustrine silts, the formation of peat bogs and marshes, all point to the prevalence of climatal conditions very similar to those which obtained during the growth of the peat bogs and forests of subsequent ages. In these older beds, however, the bogs are represented not by peat, but by seams of lignite. Upon the fluviomarine series rests the boulder-clay of Norfolk, which is said to be unstratified, and to be filled with small and large blocks of far-transported striated boulders. What we here term boulder-clay is a series of sandy brick earths sometimes more or less laminated, and occasionally fossiliferous. The local geologists recognise three boulder-clays, and these have received various names. The lowermost is termed by some the lower boulder-clay, by others the lower glacial drift; another is the upper boulder-clay of some, and the middle glacial drift of others. In addition to these there are, first, a third boulder-clay and a true northern or upper glacial drift. The variety of names assigned to these beds, and the varying opinions entertained respecting their relative ages, are sufficiently confusing. In the first place we believe these strata are widely different in character from the boulder-clay of Scotland. They rest upon the even surface of the underlying clays, which present no signs of having been ground down; the boulder-clay is not formed out of the underlying stratum; and hence it may be inferred it has not resulted from the action of an ice cap upon an emerged land. In the second place we believe the beds are marine. It is true that the clay is generally unstratified; but in the midst of it there occur beds of gravel and clay containing marine shells; and indeed these gravelly and sandy partings are more frequent as we advance inland. These characters, together with the general facies of the shells and the Scandinavian origin of many of the boulders, indicate that they are a series of marine deposits similar to, and formed under somewhat analogous conditions as, the clays, sands, and gravels of Lancashire and Cheshire. The upper surface of the boulder-clay at Mundesley, Cromer, and other neighbouring localities, is very uneven and much eroded. In most of these localities also it is covered by a gravelly or sandy layer highly disturbed, and known as the contorted drift. Subsequent to the formation of these beds, many of the Norfolk valleys have been excavated and more or less filled up. There is one example at Mundesley, where the valley is scooped out almost to the level of the old forest bed, and the hollow filled up with valley-gravel, peat, sand (sand bars), and gravel, probably a shingle beach. The Norfolk beds apparently represent all the periods of Professor Jamieson's table. The Cromer forest flourished when the land was at least 500 feet higher than it is now, and more or less connected with the continent. We have no space to discuss the question, but there is considerable probability that the forest was growing at the same time as the mountains of Scotland were enveloped in ice; the fluviomarine series point to a gradual slow subsidence of the land, during which marshes, lakes, and probably peat bogs, were prevalent. We have little doubt that some of the patches were once the sites of peat mosses, and if the opinion is a correct one, these are the oldest yet discovered, far older than the lower layers of peat in the Frith of Tay. The land still sinking the laminated clays, the boulder-clays with their associated gravels and sands were heaped up, and may represent the period of great depression; the excavation of the valley and the accumulation of valley gravels may be assigned to the second period of elevation, and the filling up of the valley at Mundesley and other places in Norfolk to a second period of depression. There is little or nothing to bear witness to a recent re-elevation. Farther north, or along the maritime margin of Lincolnshire and Yorkshire, there are clear proofs of this recent upward movement.

The post-pliocene strata of Yorkshire and Lincolnshire have recently been studied by Messrs. Wood and Rome, whose paper is published in the 24th volume of the "Quarterly Journal of the Geological Society of London." The structure of the district is so complicated that we cannot go into details to correlate the various beds with those met with on the other coasts of Great Britain; the difficulty is, moreover, enhanced by the scantiness of the fossil evidence. Stating the succession of events in the briefest manner possible, it appears that there was first a time when the land was high and covered with ice, which, sliding outwards towards the sea, ground down the oolitic, liassic, and cretaceous formations, carving out the bolder outlines of the country, forming great funnel-shaped valleys, and covering the high lands with a layer of an exceedingly chalky-white clay, entirely free from foreign boulders, unstratified and unfossiliferous. This deposit is just such a one as we should imagine would represent in a district abounding in chalk and limestones the true boulder clay of Scotland. Then followed a period of considerable depression, during which a series of purple clays with associated gravels and sands were deposited. The material composing these appears to be the red rocks of central England. The purple clays are in marked contrast with the white clay, not only as regards the colour, but also in containing northern boulders. The next deposits consist of another series of gravels and clays, termed by the authors Hessle, which occurs under circumstances implying a minor depression of the district. This we should be disposed to refer to the same period of depression, since, so far as we can gather, there is nothing below the Hessle series to indicate an immediately antecedent period of elevation. That there was an upward movement after the deposition of the Hessle clay is not improbable, if we consider the relations which this clay has with some of the deposits near the shore. These relations are thus described by Messrs. Wood and Rome:—"On the eastern slope of the Wold, however, at Kirmington, in north-east Lincolnshire (ten miles south of Hull), and at an elevation (as we estimate) of between 100 and 150 feet above the sea, corresponding to the higher limits of the Hessle clay, there occurs a deposit which, unless it belongs to that clay, and forms an estuarine portion of it, as we infer it does, has no place in the coast section. This deposit consists of a brick clay, interbedded with sands and capped by a thick bed of large, rounded, or beach-rolled flints. The clay has yielded some horns of a *Cervus*, and also the estuarine or littoral mollusca, *Scrobicularia piperata* and *Mytilus edulis*. Its isolated character (although we believe that it extends into the adjoining parish of Great Limber) coupled with its estuarine fauna, and its occurrence at almost the extreme limit of elevation to which we have been able to trace the Hessle clay, as well as the apparent continuity which it has horizontally with that clay, conspire to indicate that it is a portion of the Hessle clay formation." Assuming, then, that this peculiar deposit is the estuarine condition of the Hessle clay, we find that at Hull there are the remains of an ancient forest, the trees of which grew on a surface formed partly of the Hessle clay and partly of an estuarine silt. The trees are overlain by 20 feet of the silt abounding throughout in shells of *Scrobicularia piperata*, *Tellina solidula*, *Cardium edule*, *Littorina littorea*, &c. As this forest is now from 20 to 37 feet below high water mark the period of elevation would seem to have been subsequent to the Hessle clay. The troughs filled with gravel underlying the same silt probably belong to the same period. That there has been a subsequent depression and re-elevation is clear, since a large portion of the fens and low marshy lands of Lincolnshire are formed of this silt. Before leaving the East of England, allusion may be made to the great sheets of rolled-flint gravel spread over considerable areas in various parts of the country, and which are evidently older than the valley gravels. The thick deposits called the 'Thames gravel;' the gravel of the Cambridgeshire and Lincolnshire Fens; and that which extends for many miles along the foot of the Yorkshire wolds, are all examples of the deposit we refer to. Some, and probably all, of the gravels belong to the same period as the boulder clays of Norfolk and the Hessle clays of Lincolnshire; moreover, certain facts which cannot be detailed here would lead us to infer the probability that they belong to the same geological phase as the drifts of Strethill, Moel Tryfane, and Macclesfield. The gravels were formed when the land was so depressed that the sea extended in great bays up the broad eastern valleys; thus it extended up the valley of the Thames as far as Maidenhead; it filled the low lands surrounding the Wash as far south as Cambridgeshire; and it flowed up the basin of the Humber almost as far as Nottingham on the south, Doncaster on the west, and Yorkshire on the north. They were derived in great measure from the more central parts of England as well as from the great promontories which separated the above-mentioned bays. These bays are called areas of denudation by Mr. Wood. One of these promontories now forms the Wealden area, and in the opinion of Mr. Wood much of the denudation of that area has taken place during the glacial and post-glacial times. In connection with this, the question suggests itself whether the gravels of Pevensey flats and of Romney Marsh may not have been derived from the waste of the old Wealden district, before the formation of the present river valleys and valley gravels.

The history of the world during the post-pliocene period is so vast a subject that it is impossible to describe it fully in a single article. In order to make out the physical geography only of the period we should require to proceed from country to country, determining what lands were above and what below the sea. And to correlate the strata of each, we should have to trace out the old river valleys, lakes, forests, and estimate the amount of denudation which has taken place. We should meet with the lava streams and pumiceous ashes which issued from the then active volcanoes, many of which are now nothing more than decaying craters. In addition to all this, we should have to study the faunas and floras, in order to ascertain how they were distributed, and in what respects that distribution differed from the one at present prevailing. France, Germany, Switzerland, Norway, Sweden, Russia, North America, and many other countries, possess strata of this age. In most of them we find that they have been subjected to a series of depressions and upheavals so remarkably coincident with those of Great Britain, that we need not hesitate to refer them to some common cause. A few examples from localities far apart is all we can give in support of this assertion. The following summary by Sir Charles Lyell of Morlot's observations on the successive phases of glacial action in the Alps will answer for that part of Europe. He remarks that the phases which are plainly observable are four in number. First (1), there was a period when the ice was in its greatest excess, and the glacier of the Rhone not only reached the Jura, but climbed to the height of 2015 feet above the level of Neufchatel, and 3450 feet above the sea. Next (2) there came a time when the great glaciers retreated within the Alpine valleys so as to disappear entirely, not only from the Jura mountains, but also from all the low country between them and the Alps. The diminution of the glaciers is attributed to a general subsidence of the country of at least 1000 feet. During this period the stratified masses of sand and gravel, called the 'ancient alluvium,' were arranged and accumulated by means of rivers and lakes. (3) Again the glaciers advanced and lengthened without, however, attaining their former huge dimensions. (4) A second retreat followed, and the glaciers shrunk up into their present limits, their dissolution giving rise to another accumulation of stratified gravels, which now form terraces above the alluvial plains of existing rivers. Representatives of all these four periods are sometimes to be seen in one locality, as, for example, in the gorge of the Dranse, near Thonon. There the lowest bed is a boulder clay (1) twelve feet thick and containing blocks of Alpine limestone. It is covered by 150 feet of regularly stratified layers of pebbles. (2) Above this is another boulder-clay (3), with erratic blocks and striated pebbles. And at a short distance off terraces of stratified gravels and sands (4) occur at heights of 20, 50, 100, and 150 feet above the level of the Lake of Geneva, whose position shows that they are newer than the second boulder-clay. In some of the terraced deposits remains of *Elephas primigenius* have been discovered. Near this place there is the delta of the Tiniere, which is known to correspond in age with the 50 feet terrace. In this delta have been found layers of antique relics, arranged in chronological order, beginning with those of the Roman period near the top, and ending with those of the stone age at a greater depth. Sir Charles Lyell says that "upon the whole it is impossible not to be struck with an apparent correspondence in the succession of events of the glacial period of Switzerland, and that of the British Isles, before described. The time of the first Alpine glaciers of colossal dimensions, when that chain was perhaps several thousand feet higher than now, may have agreed with the first continental period, when Scotland was invested with a universal crust of ice. The retreat of the first Alpine glaciers, caused partly by a lowering of that chain, may have been synchronous with the period of great submergence and floating-ice in England. The second re-elevation of the Alps may have coincided in date with the re-elevation of the Alps as well as of the Scotch and Welsh mountains; and lastly, the final retreat of the Swiss and Italian glaciers may have taken place when man and the extinct mammalia were colonising the north-west of Europe and beginning to inhabit areas which had formed the bed of the glacial sea during the era of chief submergence. But it must be confessed, that in the present state of our knowledge, these attempts to compare the chronological relations of the periods of upheaval and subsidence of areas, so widely separated as are the mountains of Scandinavia, the British Isles, and the Alps, or the times of the advance and retreat of glaciers in those several regions, and the greater or less intensity of cold, must be looked upon as very conjectural."

Most of the deposits of France, Spain, and central Europe, consist of boulder-containing clays, gravels, sands, and loess similar to the beds at Thonon in general character, and, like them, they contain an assemblage of terrestrial animals and shells mingled with fresh-water species. In the great majority of cases they occupy the river valleys. Most of the contents of the caves in the same area appear to have been introduced during this period; and these, together with the stratified deposits, give frequent indications that the climate was on the whole colder than at present, and that the country was subject to great inundations, and was provided with an enormous lacustrine area.

In North America geologists have recognised, (1) a glacial period, during which the boulder clay was formed. Dana discusses the question whether it is due to icebergs, as urged by one party of geologists, or to glaciers, as urged by a second; and he decides in favour of the glacier theory, although icebergs may have been the cause of some of the phenomena along the margin of the land. He believes the land was much higher than now, and that the ice was a continuous sheet thousands of feet thick over Canada and the more northern of the United States. Next came what is called the 'Champlain epoch' (2), which is represented by fluviatile, lacustrine, and marine formations. The marine strata, containing shells, have been traced to various heights above the sea level, 100 feet near Brooklyn, 393 feet on the shores of Lake Champlain, and upwards of 400 feet on the Ottawa river. At heights much greater than this they pass imperceptibly into the lacustrine and fluviatile strata. They consist of loams, clays, and gravels, which in some cases have the same laminated character as some of the glacial marine beds of Europe; like them, also, they are frequently overlain by curiously contorted strata. The formation is in places thousands of feet thick, and its upper level gradually diverges from that of the river or of the sea as we advance north. Thus in the case of the fluviatile deposits the upper level is 35 feet above the river at Newhaven; 36 miles farther north, at East Hartford, in Connecticut, the difference is 40 feet; and then the difference gradually increases, until at Willimannsett, in Massachusetts, 178 miles north of East Hartford, it amounts to 194 feet, and at Hanover, still further north, to 216½ feet. On the north shore of Lake Superior the upper level is 330 feet above the lake. The same thing is observable in the marine beds: thus at New York they extend to 15 feet above the sea level; at Montreal to 450 feet; and in Barrow's Straits in the Arctic regions to 1000 feet above that level. The continent during this period was depressed, the amount of depression increasing from south to north. During this period the glaciers diminished, and many of the valleys scooped out in the preceding period were filled with debris. In the next (3) or 'Terrace' epoch, the land was re-elevated, the beds of the Champlain period were cut down into terraces by rivers, and the present river valleys formed. Subsequent to these there are beds belonging to the age of man; such are the flats, deltas, sea-beaches, and sand drifts which line the coasts, and the shelly marls and peats which occur in the more inland districts; notwithstanding a few points of difference, there is an evident resemblance to the European deposits of the same age. There are the same up and down movements, and the same signs of a gradual amelioration of the climate. The depression is most marked where the snow and ice were thickest and most enduring,

so that in the United States it increased from the southern limits of the drift area to the Arctic regions; while in Europe its amount appears to have been in some way dependent upon the height of the land. The enormous width of North America, and its great height as compared with Great Britain, facilitate the comparison of the contemporaneity of the submarine, marine, and supra-marine deposits; whereas in Great Britain they are so disconnected that it is difficult to prove that the supra-marine formations of southern England are of the same age as some of the submarine beds farther north. In the North American area the valleys and valley deposits appear to have been formed at a somewhat earlier phase than in England. The various strata in Canada have the names indicated in the following table. They are arranged in divisions, of which the uppermost (III.) is probably the Canadian equivalent of Jamieson's fourth and fifth periods; that marked II. is the equivalent of the glacial marine beds; and that marked I. corresponds to the boulder clay of Scotland. The beds under division II., occurring in East Canada, are chiefly submarine, and those occurring in West Canada are chiefly supra-marine.

III.

Shell marl; calcareous tufa; peat ochres; bog iron and manganese ores.
Modern alluvions.

II.

West Canada.	**East Canada.**
Algoma sand. **Artemisia gravel.** **Saugeen fresh water clay and sand.**	**St. Maurice and Sorel sands.** **Saxicava sand of Montreal.** **Upper sand and gravel of Beaufort.** **Upper Champlain clays and sands of Vermont.**
Erie clay.	**Leda clay of the St. Lawrence and Ottawa.** **Lower shell sand of Beaufort.** **Lower Champlain clay of Vermont.**

I.

Boulder formation, or glacial drift.
Auriferous drift of Eastern Canada.

In reading the foregoing paragraphs a frequent use of such expressions as 'geological phase,' 'representing,' and 'equivalents,' are applied to strata of different areas. They are employed for want of better terms, and seem to require some explanation. It will have been noticed that each country referred to has passed through a series of changes in the same order, and that certain beds or formations have been produced during each change. These are said to be the equivalents or representatives of each other because they occupy the same place in the succession of events, but it is by no means to be inferred that we regard them as contemporaneous. The question is purposely left open. It has yet to be proved what their dates are relatively to each other. It is possible, and probable, that beds of every geological phase were forming in various parts of the globe at the same time. The carse clay of Scotland may have been contemporaneous with the boulder clay of some parts of the Arctic regions. We imagine those beds were forming at the same time which were situated in the same climatal zones, and that the glacial marine beds, for example, were deposited earlier in the south than in the north. However, these are questions with which we have nothing to do. The main conclusions to which we are led are, that there is a marked geological sequence; that we can form a fair estimate of the geological age of a series of strata by a careful consideration of the circumstances under which they occur; that there has been but one cold period, not two as some geologists have contended; and that the climate became warmer by degrees. The apparent alternation of temperature arises from the land having been higher at one time than at another, and the glaciers more extended when the land was high. Nevertheless, there is no proof that at the same height above the sea the general climate was more severe during the second period of elevation than during the previous period of depression. In South America, also, there appear to be beds which are analogous to, if not the direct counterparts of, those of North America. Boulder clays abound from Cape Horn to several degrees farther north; boulders cover vast areas as far north as the 41st degree of south latitude; and fossiliferous gravels, sands, and clays stretch from the sea to several hundreds of feet above it, some of which constitute the soil of the great Pampean plains. From their nature, mode of occurrence, and fossil contents, these may be regarded as illustrating the same condition of things as the boulder clays and glacial marine deposits of this country. Their ages may be approximately the same, but on this point it would be premature to give a decided opinion until we have correlated chronologically the strata of the eastern and western hemispheres, a result which geologists will accomplish ere many years have elapsed.

Much that relates to the post-pliocene period has been left unsaid, but the deficiency is in part made good in the articles relating to man, bogs, submarine forests, caves, and glaciers. We must now turn our attention to the organisms of the period, with a view to determining how far they do or do not corroborate the inferences drawn from the stratigraphical details. This part of the inquiry also has its difficulties, and too much stress should not be laid upon the conclusions founded upon a narrow basis, although they may be couched in highly positive expressions. For example, the mere fact of a flint implement having been found beneath the leg of a cave bear or a tichorine rhinoceros, in which every bone retains its natural position, is not necessarily a proof that the man who made the implement lived at the same time or before those animals. For if the bed in which they are found be among the earliest deposited after the long period of cold, we ought to be thoroughly satisfied that the old rhinoceros had not been preserved in ice for centuries before its remains were transferred to the place where we find them. Many reasons exist for believing there was such a period of cold in the districts where such phenomena are met with; and Siberia affords abundant evidence that bodies belonging to extinct species, such as the tichorine rhinoceros, yet retain not only the ligaments uniting the bones, but even the flesh entire. Again, we ought to be prepared to carefully sift the evidence relating to extinct mammalia, more especially such as are found in the true boulder clays, and in the strata immediately overlying them. We know that a large portion of the land in high latitudes has been planed down and moulded by ice, and if there were any strata belonging to the warmer period immediately preceding the climax of the glacial period, we should naturally expect to find both them and their organic contents mingled to a greater or less degree in strata of a later date. Derived fossils are known to be frequent in all beds of post-pliocene age. There is no difficulty in recognising those which belong to the mesozoic and palæozoic rocks; but there is a difficulty in distinguishing between the fossils belonging to the early and middle portions of the post-pliocene periods, and, so far as we are aware, few attempts have been made to separate them. The difference in date would be comparatively unimportant from a geological point of view, although it might amount to thousands of years.

Dim as are the conceptions we have of the fluctuating form of the land of the post-pliocene period, of the physical events which transpired, and of the animals and plants which then flourished, still these conceptions supply to the imagination a sufficiently bizarre picture of Europe as it once was. Looked at from a broad point of view, it was at one time a continent so connected probably with other continents, that an animal could walk from Cape Horn through Greenland and Scandinavia to the Cape of Good Hope; and from the Cape of Good Hope through Palestine, the plains of Asia, and across Behring's Straits, back again to Cape Horn. He would traverse ice-fields, compared with which those of the present day are but puny representatives, and forests of unusual grandeur. The continent would give place to a wilderness of islands, and would again reappear to be clothed with woods, ice-fields, and lakes. The mammalia of the period were constructed on a gigantic scale, and all the lands south of about 55° N. lat. supported a great variety of species, many of which flourished in countless herds. Thus in that small area which is now called the British Isles, there lived contemporaneously upwards of forty species, or many more than are to be found there now. Not only this, but what is still more remarkable, many of those species were of vast dimensions, and belonged to genera, some of which are only represented now in the far north, while others are met with in the far south, as in India, South Africa, and South Asia.

On glancing over the following list, the mammalian fauna of the period has what we may call a continental facies; some of the genera are represented by their largest species; and the characteristic genera of the present continent and Africa had a wider range, more especially towards the north. Another feature will also be noticed, which is without a parallel, so far as intensity is concerned, in the present geographical distribution of mammals; viz., that genera with the largest individuals are represented by several species on the same area which have almost coincident range.

MAMMALIAN FAUNA OF THE BRITISH ISLES IN POST-PLIOCENE TIMES.

Order.	Genus and species.	
	Great Britain.	*France.*
Bimana.	Homo.	*
Carnivora.	Ursus arctos.	*
	U. spelæus.	*
	U. ferox.	
	Meles taxus.	*
	Gulo luscus.	
	Mustela erminea.	
	M. putorius.	*
	M. martes.	*
	Lutra vulgaris.	
	Canis vulpes.	*
	C. lupus.	*
	Hyæna spelæa.	*
	Felis catus.	
	F. lynx.	
	F. (antiqua) pardus.	
	F. leo, var. spelæus.	*
	Machairodus latidens.	*
Artiodactyla.		
	Megaceros Hibernicus.	*
	Alces malchis.	*
	Cervus tarandus.	*
	C. Browni.	
	C. capreolus.	*
	C. dicranios.	
	C. elaphus.	*
	Ovibos moschatus.	*
	Bos primigenius.	*
	Bison priscus.	*
	Hippopotamus major.	*
	Sus scrofa.	*
Perissodactyla.		
	Equus fossilis.	
	Rhinoceros etruscus.	
	R. megarhinus.	
	R. Merckii.	*
	R. tichorinus.	*
Proboscidea.		
	Elephas meridionalis.	*
	E. priscus.	
	E. antiquus.	*
	E. primigenius.	*
Cheiroptera.		
	Rhinolophus ferrum equinum.	
	Vespertilio noctula.	
Insectivora.		
	Sorex moschatus.	*
	S. vulgaris.	*
	Talpa europæa.	
Rodentia.		
	Lemur sp.	
	Lepus cuniculus.	*
	L. timidus.	*
	Lagomys spelæus.	
	Spermophilus erythrogenoides.	*
	S. citillus.	
	Arvicola pratensis.	*
	A. agrestis.	*
	A. amphibia.	*
	Mus musculus.	*
	Castor trogontherium.	
	C. fiber.	*

In the corresponding latitudes of eastern Europe 28 species of post-pliocene age are known. Most of these are identical with English species. Amongst others may be cited, *Ursus spelæus*, *Mustela martes*, *Lutra vulgaris*, *Canis vulpes*, *C. lupus*, *Hyæna spelæa*, *Felis spelæa*, *Cervus tarandus*, *Bos primigenius*, *Bison priscus*, *Merycotherium*, *Sus scrofa*, *Equus fossilis*, *Elasmotherium*, *Rhinoceros tichorinus*, *Elephas primigenius*, and representatives of the dormice, hamsters, voles, and rabbits. In general features the faunas were similar in both places, but whereas *Hippopotamus* and *Machariodus* have not as yet been found in the east, so *Merycotherium* and *Elasmotherium* appear to be absent in the west. Again, the cave bear was unusually abundant in the east, while the cave hyæna was comparatively rare. In England, the hyæna was abundant.

In France, the fauna was very similar to that of England as indicated by the foregoing table, but in addition to these, there were some which have not been recorded in the English post-pliocene deposits. They are, *Capra hispanica*, *Antilope rupicapra*, *Antilope Saiga*, *Castor europæus*, *Arctomys marmota*, *Arct.* n. sp., *Felis lynx*, *Felis* sp. allied to the leopard, and *Hyæna striata*. In the southern part of France, as along the slopes of the Pyrenees, the caverns and the ossiferous strata in the river valleys contain the remains of certain species which connect the fauna of England in the post-pliocene age with the African fauna of the present day. Thus, in the caverns of Aurensan, the African rhinoceros and lion, or animals scarcely different from them, have left their remains in association with the mammoth and its associates. M. Lartêt, who has so long and so successfully studied the palæontology of this period, has convinced himself, not only that certain species came in and died out during this epoch, but that, so far as France is concerned, he has been enabled to trace the order in which they disappeared. This order serves as a kind of chronological table, and if confirmed, will be exceedingly useful. His idea of the relative antiquity of those species is expressed in the following list, in which the first-mentioned was the first to disappear from the soil of France, either by extinction or by emigration to other lands, and the rest followed in the order indicated :—

1. Ursus spelæus.
Hyæna spelæa.
Felis spelæus.
2. Elephas primigenius.
Rhinoceros tichorinus.
3. Megaceros Hibernicus.
Cervus tarandus.
4. Bison priscus.
Bos primigenius.

It is not settled that their departure was precisely in the order given, but the sequence is considered to be well marked for the groups bracketed together. Man appeared before the last on the list had retired from the country, but it is a disputed point how much earlier he may be traced back. Some believe that he was the contemporary of the old cave-bear, and others will not admit that he dates further back than the age of the rein-deer. The evidence upon which both these conclusions are based, is given under Man, E. C. S. In examining the fauna farther south, or that of the Mediterranean area, we come upon fresh links with the fauna of the continent to the south of it, in the form of the African elephant, and the greater abundance of *Hippopotamus major;* while new species (such as a new species of *Lagomys* and a pigmy elephant), unknown further north, give a peculiarity to the district. In America there were two well-marked faunas, one of which prevailed in the north, and the other in the south. In N. America, the *Elephas primigenius* ranged from beyond the Arctic circle as far south as the Alleghany mountains, and was replaced from there to Mexico and Peru by *E. columbi*. *Mastodon giganteum*, which generally accompanies the mammoth in America, is one of the most characteristic forms of that continent; although in Europe the genus appears to have died out before post-pliocene times. The *Castoroides ohioensis* represents the European beavers. The horse had its species, but these were different from those of Europe, and they died out before the advent of the white man. The genus *Bos*, was represented by several species; amongst which, *B. latifrons*, whose remains occur in the valley of the Mississippi, is the best known. It far exceeded the recent bison in size. There was also a stag, *C. americanus*, more gigantic even than its congener the Irish elk, herds of which flourished in the same area that supported *Equus americanus*, the giant of the equine group. The feline tribe was represented by *Felis atrox*, a lion of a larger build than the cave-lion of Europe. The remains of the bear have been rarely found. A tapir, *T. mastodontoides* has been found in Kentucky, and an animal nearly allied to it, called *Harlanus americanus* by Owen, in Georgia. The peccari has also been detected in the same district as the tapir. Associated with these, were a number of forms which give a peculiar aspect to the fauna of North America. They comprise forms of edentate creatures, allied to the ant-eater and armadilloes of the present day, but the rivals in size of the mammoth, oxen, and horses, with whose remains their own are found. Amongst others may be mentioned, *Megatherium mirabile, Megalonyx Jeffersoni, Mylodon Harlani*. In America then, as in Europe, the animals which preceded those which now hold possession of the land were, generally speaking, remarkable for their enormous dimensions; and in the New World, as well as in the Old, there appears to have been a more northern extension of types which are now regarded as characteristic of a southern zone. In Europe, the elephant, the rhinoceros, the hippopotamus, the lion, and the hyæna existed much farther north in post-pliocene times than they do now; and in America, the edentata seem to have had a similar extraordinarily high northern range. In South America, the *Edentata* were well represented, but the fauna of this part of the continent was for the most part specifically distinct from that which prevailed in North America. In both North and South America, however, there appears to have been remarkably few carnivorous animals; a feature in which they present a marked contrast with Europe, and the contrast is particularly noticeable between South America and Europe. As yet, but three species of carnivores have been found in South America, viz., a bear, *Ursus bonariensis*, similar in size to the cave-bear of Europe; a feline, somewhat smaller than the common lion; and a dog, which has been named *Canis azarea*. Amongst the rodents there are *Hydrochœrus capybara*, which still exists, and species of *Kerodon* and *Ctenomys*. Amongst the pachyderms were two mastodons (*M. andium* and *M. Humboldtii*), specifically different from that of the north; two species of horse, *E. neogæus* and *E. Devillei;* and two species of *Macrauchenia*, viz., *M. patagonica* and *M. boliviensis*, which were long-necked herbivorous pachyderms. The ruminants comprised *Toxodon platensis*, four species of *Nesodon*, and three species of *Auchenia*. *Dicotyles collaris* was the South American peccari. The *Edentata* were numerous and large. The *Megalonyx Jeffersonii*, already referred to as having existed in North America, extended its range as far south as the plains of Patagonia. The *Mylodon* had two southern representatives, named *Darwinii* and *robustus*. Closely allied to the *Mylodon* in structure was its congener, *Lestodon*, of which two species have been recorded. The *Scelidotherium leptocephalum* appears to have been a large ant-eater. *Megatherium* had two species in the south, viz., *M. Cuvieri*, and another not named. *Glossotherium* appear to have closely resembled the recent aard-vark. The genus *Glyptodon*, of which several species have been found, was remarkable for the huge massy carapace with which it was provided. *Schistopleurum*, was another genus having the same peculiarity. Many of these, together with other species, have been exhumed from the Brazilian caverns; and among them were several carnivora, such as moderate-sized felines, dogs, &c. The most remarkable is a species which has been considered to be first a *Hyæna*, then a new genus, *Smilodon*, but which is said to yield the characteristics of a *Machairodus*. The deposits of South America, exclusive of the Brazilian caverns, have yielded 36 mammalian species, of which 3 were carnivora, 4 rodents, 14 pachyderms and ruminants, and 15 edentata. In the caverns there have been detected the remains of 115 species, distributed as in the following table; in the last column we have added the number of species still existing in Brazil, in order that the general character of the 135 species now living may be compared with the older fauna.

	Genera.	Species.	Living species.
Quadrumana . .	4	6	11
Cheiroptera . .	3	7	31
Rodents . . .	15	32	44
Marsupials. . .	1	7	14
Carnivores . .	9	18	17
Ruminants. . .	4	7	5
Pachydermata .	9	10	3
Edentata . . .	13	28	10

The Australian continent, whose present fauna and flora is so distinct from that of other geographical areas, appears to have been characterised by its mammals being chiefly marsupials,—a peculiarity which some think may be explained by its having been long separated from all other parts of the world. In 1844, Strzelecki described a tooth, which was bought from an Australian, and was said to have come from the plains of the interior. This tooth is unquestionably that of *Mastodon andium;* but, considering the source from which it has come, and the important bearing which the occurrence of a mastodon tooth in Australia would have upon the prevailing notions respecting the geographical distribution of animals, as well as the past history, we should do well to pause with Dr. Falconer before accepting the discovery as a genuine addition to science. With this exception, all the remains which, from their position and mode of occurrence, may probably belong to the post-pliocene period, are marsupials. Most of them belong to genera still represented in Australia, but the others are now restricted to Van Diemen's Land. Thus *Dasyurus*, of which one species now occurs in Van Diemen's Land, was formerly represented in Australia by *D. laniarum;* and *Thylacinus*, now restricted to the same small neighbouring island was formerly represented in Australia by *T. spelæus*. The *Thylacoleo carnifex* of Owen was a marsupial carnivore as large as a lion. There were several species of kangaroos, viz., *Macropus affinis, M. Atlas*, and *M. Titan*, of which the first was the size of the largest living species, and the latter two considerably superior in size; and *Hypsiprymnus spelæus*, which has been found along with the remains of the still living species, *H. hydromis*, and the dingo dog. There were two wombats, viz., *Phascolomys Mitchellii* and *P. gigas*, the latter as large as a tapir. There was also a marsupial (*Diprotodon australis*), representing the gigantic pachyderms of other continents, and which was equal to the *Hippopotamus* in dimensions. *Nototherium inerme* and *N. Mitchelli* were species somewhat similar to *Diprotodon*. No mammals have yet been reported from New Zealand, although it appears to have abounded in large wingless birds.

In this rapid resumé of the post-pliocene fauna, we have purposely avoided entering into the various discussions which many of the facts mentioned tend to provoke, nor have we said anything as to the structure of the species. Details on this latter branch of our subject will be found scattered throughout the zoological articles in E. C. and E. C. S., and those on the former can only be cursorily alluded to here, although some will be treated at greater length under other headings. One of the most remarkable facts connected with this old fauna, is the greater size of the species as compared with their most nearly allied recent representatives; and this phenomenon, be it observed, is not confined to any particular continent, but is general throughout the world. It is further remarkable that the diminution appears to have been generally coincident with the gradual increase of warmth, at least, in the higher latitudes. Doubtless, the explanation which applies to one area will apply to all the others.

We have treated the fauna of this period as a whole; but, as has been hinted, some of the species only lived during a portion of the period. There are no indications that the fauna lived on for a prolonged period without undergoing change, and that then a number of species were swept out of existence by some cataclysmic disaster. It would rather appear that the process of extinction and of full establishment was gradual. The species was not exterminated at a single stroke, but its disappearance was in many, and probably in all, cases preceded by the restriction of the species within narrower limits; or, as some naturalists believe, by modifications, whereby the old form gave rise to some others which are now ranked as distinct species. Hence, in forming opinions respecting the post-pliocene fauna, it is highly important that we should be able to trace the precise stratigraphical distribution of each distinct form, whether it be a variety or a species, so as to be able to form a clear conception of the geographical distribution at various successive epochs, of the fluctuations which that distribution underwent from one epoch to another, and of the connection between these fluctuations and the changes in surrounding conditions, such as alteration of climate, the shifting outline and surface contour of lands, and all the results which followed therefrom.

(D'Archiac, *Faune quaternaire*, 1865; Geikie, *On the Phenomena of the Glacial Drift of Scotland* (*Trans. Geol. Soc. Glasgow*, vol. i.); Jamieson, *Q. Journ. Geol. Soc.* xxi. p. 161—203; xxii. p. 261—281; Taylor, Binney, Wilkinson, and others in *Transactions of the Geol. Soc. of Manchester*; Binney, Hull, Darbishire, Morton, and others, in *Proceedings of the Literary and Philosophical Society of Manchester*, for 1861—1867; Godwin-Austen, Symonds, Phillips, Startin, Brodie, and others, in *Brit. Association Reports* for 1862 and subsequent years; Lyell, Sir C., *Elements of Geology*; Lyell, Sir C., *Antiquity of Man*; Dana, J. D., *Manual of Geology*; Dawkins, *Q. Journ. Geol. Soc.*, xxv. p. 192 *et seq.*; &c.)

PRIMULA. Botanists have long been familiar with the fact that a large number of plants develope flowers having two distinct forms; in the one there are stamens but not pistils, while in the other the pistils only are present. It is also known to most persons that the stamens develope an anther or case containing a powder, commonly known as pollen; that the pistil consists of the ovary connected by a slender column with a terminating protuberance smeared over with a sticky substance, or the stigma; and that for the production of a sound seed it is necessary that the pollen be dusted over the stigma, so as to permit of their developing tubes which shall penetrate down the style into the ovary. If then the pollen is developed in one flower, and the stigmatic surface and ovary occur in a second, it is clear there must be some means of conveying the pollen from the one flower to the other. Where the two kinds are produced by the same plant it might be supposed that the transfer would generally be effected by the wind; and that this agency might suffice even when the two kinds of flowers are developed on different plants. In many cases the wind may be efficient, but ordinarily the carriers are insects. In another large group of plants the pistils and stamens occur together in the same flower; in which case it may generally be supposed there can be no difficulty in the pollen being transferred from the anther to the stigma by the plant itself, without the extraneous assistance of wind, insects, &c. Moreover, to many persons it would seem clear that in such plants the fertilization of the seed will be almost always effected by the pollen coming in contact with the stigma of the same flower by which it was itself formed. Close observation and careful experiment, however, tend to show that such suppositions are erroneous, and that the fertilization of seeds depends upon a far more complicated process than is at first sight apparent. A good illustration of this remark is afforded by the genus *Primula*, some of the species of which form the commonest and most cherished flowers of our meadows, lanes, and woods. Owing to their abundance and popularity it is not surprising that not only gardeners, but even children have recognised that cowslips and primroses are not all alike. In each case there are two sets of blossoms. The gardener calls one the "pin-eyed," and the other "thumb-eyed;" while the children select the one set in preference to the other, on account of the greater facility with which such blossoms can be linked together into necklaces. But what is surprising is that scarcely any gardener or child attempts to ascertain what the difference is, and in what way it is connected with the welfare of the plant. Indeed, it is only within the last few years that any one has given serious attention to such points; and he who was amongst the first to do so displayed such sagacity, that the phenomena which he described and the results which he displayed, formed the basis of a paper which promises to be the forerunner of a most important series of discoveries relating to the fertilization, hybridization, and development of hermaphrodite plants. The observer we refer to is Charles Darwin. He indicates that in the "pin-eyed" blossoms the tube of the corolla is a deep pit in the midst of the petals. At the bottom of the tube is a spherical mass forming the extremity of the ovary; from it rises a slender stalk supporting the stigma, which is just flush with, or projects slightly above, the mouth of the tube, the whole reminding one of a pin with its point downwards, and its head just visible in the centre of the flower. From this circumstance we suppose the appellation "pin-eyed" is derived. About half-way up the tube, and attached to its sides, are the anthers, or pollen cases. Above the anthers the tube slightly widens outward, so as to be somewhat wider than the diameter of the stigma. The space thus left allows of the introduction of the thread. Mr. Darwin calls this set of flowers the long-styled. In the "thumb-eyed" set, the style is so short that the stigma it supports only reaches the same height in the tube as the anthers in the long-styled flowers. Above this level the tube retains its diameter until close to the mouth, where it slightly expands. At the point where the expansion commences the anthers are attached to the side of the tube, and their upper ends are level with the mouth of the tube. They are so closely contiguous that a thread can with difficulty be introduced into the tube. This set is called "short-styled" by Mr. Darwin. These are the main structural differences; but there are numerous others. Thus in the long-styled flowers the stigma is globular; in the short-styled it is oblong; in the long-styled group the stigma has a rougher surface, the pollen grains are much larger, as well as differently shaped, than in the short-styled plants. The same phenomena are observable in many other species of *Primula*, but not in all, as also in many other genera. The short-styled plants generally produce a greater number of seeds than the long-styled. Hence we see that the difference of structure is accompanied by difference of fertility. In some species, which will be referred to hereafter, the stigmas and anthers are on the same level. However, confining our attention, for the present, to the long-styled and short-styled plants, we would mention that the arrangement of the anthers above the stigma in the short-styled flowers appears to be exceedingly favourable to self-fertilization of the flower by the dropping of the pollen when the anthers burst; while that which prevails in the long-styled form, where the stigma projects far above the anthers, would be unfavourable to any self-fertilization, or even fertilization at all, supposing currents of air to be the chief pollen carriers. By a series of experiments which cannot be detailed here, Darwin proved that the fertilization is mainly effected by the pollen which is carried about from flower to flower by insects. He pointed out in what way the similarity in the height of the anthers of the one set of flowers with that of the stigma in the other, insures the pollen being transferred to the stigma; and makes the following observation on the subject:—"In all the species of *Primula*, the pollen readily coheres to any object. In all that I have observed the pistils and stamens differ in length relatively to each other, in the different species; yet in the two forms of the same species, the stigma of the one form stands at exactly the same height with reference to the corolla as the anthers of the other form. If the proboscis of the dead humble bee, or a thick bristle, or rough needle be pushed down the corolla, first of one form and then of the other, as an insect would do in visiting the two mingled forms, it will be found that pollen from the long-stamened form will adhere round the base of the proboscis, and will be left with certainty on the stigma of the long-styled form; pollen from the short stamens of the long-styled form will also adhere a little above the tip of the proboscis, and some will generally be left on the stigma of the other form. Thus pollen will be carried reciprocally from one form to the other. In withdrawing the proboscis from the long-styled form, with pollen adhering near the tip, there will be a good chance of some being left on the flower's own stigma, in which case there will be self fertilisation; but this by no means always occurs in the short-styled form; on the other hand (and it is important to remember this), in inserting the proboscis between the anthers situated at the mouth of the corolla, pollen, as I frequently found, is almost invariably carried down and left on the flower's own stigma. Moreover, minute insects, such as *Thrips*, numbers of which I have observed in primrose flowers thickly dusted with pollen, could not fail often to cause self-fertilisation. We positively know that the visits of large insects are necessary to the fertilisation of the species of *Primula*; and we may infer from the facts just given that these visits would carry pollen reciprocally from one form to the other, and would likewise tend to cause self-fertilisation, more especially in the short-styled (*i.e.*, long-stamened) form." Such observations naturally suggest two questions; of which one refers to the kind of insects which mostly frequent such flowers, and the second to the diverse results which may follow from the different ways in which the pollen can be applied. As regards the first question, it seems that, so far as direct watching has gone, insects have rarely been seen to visit primroses in the day time, so that Darwin conjectures that moths, or the insects which fly about in the twilight hours, are the pollen carriers. Observations are much wanted on this point. As regards the second question, the results vary in a remarkable degree from great fertility to absolute sterility. In the case of the primrose and cowslip the greatest number of seeds are formed when the pollen is transferred from the anther of one flower to the corresponding stigma of another, that is, those which have the same relative position. This kind of union is designated *heteromorphic*, as distinguished from the *homomorphic*, in which the pollen is transferred from the anther to the stigma of the same flower. Curiously enough many of the homomorphic unions are less fertile than the crosses between two distinct species. The pollen has different degrees of power according to the mode of union. Experiments have been carried out to ascertain the relative results of homomorphic and heteromorphic unions both in the same and in different species. It would be difficult to make these plain without many details and tables; but Messrs. Darwin and Scott have arrived at some remarkable conclusions. Thus it is found that some of the unions between different species are more fertile than many of those between flowers of the same species. If this is true, either the old physiological test of a species must be abandoned, or botanists have entirely failed to make out what are the marks of specific distinction. In order to give the reader some idea of the present state of the inquiry, we give Mr. Scott's summary of the results of his experiments. "The species of *Primula* are variously estimated by authors, many of the forms reputed specific by one being considered as mere varieties by another. Steudel, for example, in his 'Enumeratio Plantarum,' admits 85 species, whereas De Candolle ('Prodromus') gives only 61—a difference of 24 doubtful forms. Of these varieties or species, then, I have given the sexual characteristics of 54; 36 of which are truly dimorphic, presenting both long and short-styled forms; 13 in which the long or short-styled forms have alone been observed by me; and 5 species and one variety, with non-dimorphic characteristics, that is, presenting stamens and pistils of an equal length. The allied genera, *Hottonia* and *Aretia*, have also truly dimorphic species; whereas other allied genera, *Dodecatheon*, *Soldanella*, and *Cortusia*, are very generally characterised by species presenting the structural characteristics of the long-styled forms only, without, however, any decreased fertility arising from their hermaphrodite conjunctions. The general differences of the two sexual forms may be thus briefly summed up. First, the long-styled forms have pistils equalling in length the tube of the corolla; stigmas usually larger and rougher; stamens attached to, or frequently below, the middle of the corolla tube, whose diameter is thus expanded upwards; pollen grains generally smaller and more transparent. Secondly, in the short-styled form the pistil is short, not rising above half way up the corolla tube; stigma generally smoother and depressed on the summit; stamens attached to the mouth of the corolla tube, causing an abrupt expansion; pollen grains generally larger and more opaque. According to all the trials these structural differences are accompanied by equally remarkable functional differences, the pollen of the long stamens being alone adapted to fertilise the long pistils, and the pollen of the short stamens the short pistils. By applying, on the other hand, either form pollen to its own form stigma, *i.e.*, effecting a homomorphic union, the degree of fertility relatively to the above, or heteromorphic union, is greatly decreased. Analogous, though less striking, functional differences, however, occur without any appreciable change of structure, as shown by the *P. verticillata*, *e.g.*, yielding a much higher grade of fertility by its diœcious than its hermaphrodite conjunctions. Such an instance from a genus whose members are generally characterized by a sexual dimorphism, naturally leads me to regard it as indicative of the acquirement of similar characteristics. An objection to this view may be urged from the occurrence of species which, having no immediate affinity with any structurally dimorphic species, nevertheless present individuals incapable of fertilisation by own pollen, though perfectly susceptible to reciprocal fertilisation, either with another individual of the same species, or one of a distinct species. To this category, at least, those who disbelieve in the genetic affinities of organic beings will no doubt refer the case of *P. verticillata*, and simply regard it as further illustrative of our ignorance of the conditions upon which sterility, in its varied grades, depends. Those, on the other hand, who believe in the existence of these genetic relations, will look with intelligent interest upon these functional peculiarities of the *P. verticillata*, and regard them, mayhap, as the primary indications of a tendency to assume those remarkable sexual characteristics of the correlated species, and thus presenting an illustration of incipient dimorphism. The usual differences in the fertility of the heteromorphic and homomorphic unions will be best appreciated by giving the mean results from the unions of several species. Thus taking the five heteromorphic and homomorphic unions given above, namely, *P. auricula*, *Sikkimensis*, *cortusoides*, *involucrata*, and *farinosa*, we see, from the mean results of these combined products, that for every 100 seeds yielded by the heteromorphic unions only 24 are yielded by the homomorphic unions; the heteromorphic thus exceeding the homomorphic unions in about the proportion of 5 to 3. I have also shown the remarkable fact that the pollen of a distinct species will produce a much higher grade of fertility than an ordinary homomorphie union, *i.e.*, a flower's own pollen. It is well known that A will fertilise B, and B will not fertilise A. I have given several instances of this law with *Primulas*. I have also shown the new and remarkable fact that of the two forms of the same species, the pollen of the one, but not of the other, will fertilise a distinct species. For example, the long-styled *P. Palinurii* can be fertilised readily by pollen of the long-styled *P. auricula*; yet after numerous trials I have failed to effect a single union between the long-styled form of the *P. Palnurii* and the short-styled *P. auricula*. How utterly inconsistent, then, are such facts with the teachings of those who would have us believe that an absolute causal relation exists between the sterility from hybridism and systematic affinity. On the other hand, how unequivocally do these cases show us that the greater or less facility of one species to unite with another is, as Mr. Darwin has sagaciously argued, 'incidental on inappreciable differences in their reproductive systems. And that there is no more reason to think that species have been specially endowed with various degrees of sterility to prevent them crossing and blending in nature, than to think that trees have been specially endowed with various and somewhat analogous degrees of difficulty in being grafted together in order to prevent them becoming inarched in our forests.' Probably the most remarkable result from my observations is that when the dimorphic species cease to be dimorphio, their reproductive functions are greatly modified. Thus, in the case of the cowslip, for example, we have seen that an ordinary homomorphic union yields about 14 seeds per capsule, the heteromorphic about 24 seeds per capsule, whereas the form with stamens and pistils of an equal length yields, when fertilised with its own pollen, 34 seeds per capsule. Thus the non-dimorphic form by its own pollen exceeds, first, the homomorphic unions in the proportion of 5 to 2; and, secondly, the heteromorphic in the proportion of 3 to 2. Again, from the four different unions of the long and short-styled forms with the non-dimorphic form, the seed results in each case fall considerably below an ordinary homomorphic union; thus the mean results of the unions of non-dimorphic with long and short-styled forms is 6 seeds per capsule, whereas the pure homomorphic unions of the latter give an average of 13 seeds per capsule, that is, as 2 to 1. Connected with this are the remarkable changes in the fertility of the coloured varieties of the primrose, the red variety yielding no seed when fertilised by pollen of either yellow or white varieties; the reciprocal crosses of these, *i.e.*, the pollen of the red variety applied to the stigmas of the yellow and white, are also absolutely sterile. On the other hand, fertile unions may be effected by the reciprocal crossing of the yellow and white varieties, though in every case we have found that the average seed result of such unions is considerably under that of the pure unions of these forms. Whether or not the ultimate tendency of dimorphism is a complete separation of the sexes, I think we have the clearest testimony that dimorphism has not always been a genealogical characteristic; and furthermore, that the two forms did not *per saltum* assume their structural and physiological characteristics. I here allude to the evidence afforded by the non-dimorphic cowslip, namely the resumption of perfect hermaphrodism, and the occasional production of intermediate stages between this and the normally dimorphic. These, taking us back in the genealogical line, show us an original non-dimorphic progenitor, and the graduated plan by which it gave rise to a dimorphically characterised race." These conclusions are so remarkable and unexpected, that one would like to know what evidence some of our common species afford in support of them.

(Darwin, C., *Proc. Linn. Soc. Lond.* vi., Botany, pp. 77—96; Scott, *ibid.* viii., Botany, pp. 78—126).

PSILOCARYA, a genus of cyperaceous plants, of which Steudel describes thirteen species, all of them American.

PSITTACIDÆ [E. C. vol. iv. cols. 475—488]. The ancient nations which flourished at the commencement of the Christian era have several allusions to parrots in their literature, as already noticed in E. C.; but so far as their statements enable us to judge, they were acquainted with but one species, viz., *Palæornis torquatus*. From the fourth to the fifteenth centuries parrots are scarcely mentioned; and no new species nor new facts relating to old species were put on record. The revival of learning in the middle ages led men to search for unknown lands, and hence arose a desire to learn something about the remarkable plants and animals which came under their notice. Marco Polo was among the first of moderns to make any mention of parrots. The voyages of Columbus are perhaps the earliest record of the parrots of America. When he was approaching land, although not within sight, a flock of birds, said to be parrots, passed by the ship. This instilled fresh spirits in the hearts of the forlorn voyagers, who were cheered up by the words :—"Forwards, these birds will not lead us on in vain." Very soon after Watling's Island was sighted. From this locality, as well as from the fact that the birds were far out at sea, it is not likely that they were really parrots. At the present time they are not known so far north in a wild state. The first parrots were brought to England from America in 1504: a proof that the English must have already extended their researches as far south as 42° N. lat. After this, new species were constantly being discovered and described; and by the beginning of the nineteenth century they were considered sufficiently numerous and interesting to form the subject of a special monograph, entitled, "Histoire Naturelle des Perroquets, 1801—1803," written by Levaillant. He figured 137 species, but of these only 84 are considered to be well established. In 1820, Kuhl's 'Conspectus Psittaceorum' was published. It contained descriptions of 209 species, but if those which are insufficiently described, or are treated under one or more names, be omitted, there remain 158 which may be considered to be well established. In 1832 appeared the third monographic work on this group; viz., Wagler's 'Monographia Psittaceorum.' Excluding a number of doubtful species, he was acquainted with 197 good psittacine species. In 1837—1838 a continuation of Levaillant's 'Histoire des Perroquets' was brought out by Bourjot St. Hilaire, in which 94 species not mentioned in Levaillant's work are described and figured. In 1857, appeared the first part of a work, 'Iconographie des Perroquets non figurés dans les publications de Levaillant et de Bourjot St. Hilaire,' by De Souance, Prince Lucien Bonaparte, and Blanchard; twelve parts have been issued, but the work is not finished. In 1867 appeared vol. i. of Otto Finsch's 'Die Papageien; monographisch bearbeitet.' In this work the number of well-established species is considered to be 350. In addition to these monographical works numerous accounts and descriptions of a more or less elaborate character have been given to the scientific world. We can here only mention a few of the more important of these which have been published within the last thirteen or fourteen years. The 'List of the Specimens of Birds in the British Museum, part iii. Psittacidæ, 1859,' is an invaluable guide to the synonyms of the group. Wallace's explorations in the archipelagoes of the east have added much to our knowledge of the geographical distribution of the species which reside there; and his remarks on the subject will be referred to presently. The British Museum has the richest collection of these birds, comprising representatives of 310 species; the museum at Leyden comes next, with 270 species; and amongst private collections, we believe those of Major Kirchhoff and Dr. Sclater are the most complete.

Although 350 species of parrots are recognised, all that is known of the great majority of them consists of a name and a description of the external form. We have much to learn respecting their habits, and the many interesting features which indicate the bond of connection between the individuals and the world amidst which they live.

Most parrots move about in flocks; and these are frequently of considerable extent. Thus Waterton describes the sight of thousands of *Araras*, and Schomburgk saw the *Chrysotis amazonica* collect in such swarms that the boughs of the trees broke beneath their weight. Sometimes more than one species occur in the same flock. Gould has seen four species of *Trichoglossus* feeding on the same tree, and the species of *Chrysotis* and *Conurus* are frequently intermingled together. The larger species generally keep in distinct flocks. There is but little migration in the members of the family; the parrots of Van Diemen's Land make periodical visits to South Australia, and the South Australian species migrate to the north coast; and some of the American species seem to wander from one part of the country to another, urged apparently by the scarcity of food in one place, and its abundance in another.

The majority of parrots are essentially arboreal birds; and they frequent the sides of the streams rather than the impenetrable thickets of wide-spread forests. Some species frequent open spots; such as *Euphema elegans*, which collects in hundreds round the smallest pools of water in Australia; and *Callopsittacus Novæ Hollandiæ*, which so constantly remains in the neighbourhood of streams and ponds that the Australian travellers in the interior of that continent feel sure water is at hand when they see a flight of these birds. The ground frequenters are more abundant amongst the Australian species than those of any other part of the world; and these belong for the most part to the genera *Platycercus*, *Euphema*, *Melopsittacus*, and *Pezoporus*, which feed chiefly on the seeds of grasses. The longer tarsus in these species has a relation to their more cursorial habits. The *Conurus patagonia* is remarkable for the variability of its habits, being arboreal where trees abound, and terrestrial where they are scanty. The neighbourhood of dwellings, or even towns, does not appear to drive these birds from their usual haunts. Thus Prince Max noticed *Sittace nobilis* amongst the trees in the town of Villa Vicoza. Gould says Hobart Town and Adelaide are constantly visited by flights of parrots, which chase each other down the streets as the swallows do in English towns; he has even seen flocks of *Platycercus flaviventris* frequent the farm yards for the sake of the grain they can find. *P. icterotis* attacks the fruit in the gardens of the Australian settlers; while *Brotogerys pyrrhopterus* does the same thing in the gardens of Central America. The common *Palæornis torquatus* nestles amongst the palm trees in market-places, undisturbed by the concourse of men about them.

They are regular in their habits: as soon as the day dawns they make short journeys to the usual feeding-place, tumble and bathe generally about the same time, pass the hot midday in some shady, leafy tree; again feed in the cool of the evening; and then retire to rest in the highest and most leafy trees. A few species in North America roost in the hollows of trees. As many as possible crowd into the hole, and the remainder cling to the bark close by the entrance. It is some time before quiet ensues, since there is generally much screaming and struggling in order to obtain the best places.

The colour of the species generally assimilates to that of the places which they frequent. Thus, green is a prevailing tint, and so nearly resembles the leaves amidst which they climb that they are not readily seen. Many of the ground species are more or less grassy green. The ear-piercing cries of parrots are familiar to most persons; but there are a few species which possess a mimic voice. The *Platycercus hæmatonotus* has a song, which Homyer has compared to that of a thrush; the notes of *Palæornis cyanocephalus*, *Euphema elegans*, and *Coryllis galgulus*, are more or less pleasant. The note of some species is a melodious piping; thus Gould says of *Platycercus icterotis*, that "its note is a feeble, piping kind of whistle, which is occasionally so much lengthened and varied as almost to assume the character of a song." Almost every species has a note peculiar to itself.

The food is, in most species, of a vegetable nature; but some of the *Trichoglossidæ* derive a portion of their support from the insects which they swallow along with the sweet juice they lick up from the nectaries of flowers. The strong-billed species of *Calyptorhynchus* tear away the bark of trees in order to get at the coleopterous larvæ concealed beneath it. Some *Platycerci* combine a few insects with their ordinary vegetable diet. The form and structure of the bill seem to be intimately connected with the nature of the food. *Microglossus aterrimus* and *Sittace hyacinthina* live on the seeds of *Canarium*, *Astryocaryum tucuma* and *Acrocomia lasiospatha*, which are enveloped in a shell so tough and hard that it requires a hammer to break it. The uncommonly strong beaks of these birds perform the work with apparent ease. *Sittace chloroptera* feeds chiefly on the nuts of *Lecythis ollaria* and *Cocos coronata*. The large American parrots attack the *Bertholletia excelsa*. Few or no other animals can break these hard shells; but many mammalia follow the parrots in order to feed upon the broken fragments which they drop. The food is, however, not always hard. Thus *Plyctolophus nassica* eats the roots of orchids: some Australian species derive their nourishment from the seeds of *Eucalyptus*, *Casuarina*, and *Banksia*; *Conurus carolinensis* banquets upon *Platanus occidentalis*, *Juglans olivaformis*, *Cupressus*, and *Xanthium strumarium*. Some species belonging to the genera *Platycercus* and *Coryllis* feed on blossoms and buds; *Conurus cactorum* lives almost exclusively on the fruit of cacti; *Stringops* subsists on mosses and berries. Many of the Australian species, including *Platycercus*, *Euphema*, *Melopsittacus* and *Pezoporus*, are grass eaters. The long-tongued species of *Domicelli*, *Trichoglossus*, and perhaps *Nestor*, live on the juices of the ever-blooming *Eucalypti*.

Parrots attain a great age. Levaillant mentions an individual 73 years old, which had, however, lost its sight and memory. Vieillot saw one 80 years old, which had many indications of advanced decrepitude. M. Grassi, of Cervione, knew of a bird, a species of *Ara*, whose history was known for at least sixty-five years. This bird was obtained in Spain in 1799 or 1800, and had since lived in Italy and in Italian families. As it knew several words of Spanish, and as it is conjectured they do not acquire the faculty of repeating phrases before the end of their second or third year, this would give a probable age of about 68. This bird gradually lost its sight, becoming blind in 1858. Its beak had grown so long and curved as almost to penetrate its breast. Humboldt mentions an old parrot which he saw amongst the Maypures. Its age was unknown, and probably was not so great as in the cases already recorded. The bird was, however, an interesting individual upon other grounds. It lived amongst the Maypure Indians, but it spoke phrases which these people did not understand, since they were couched in the Aturian language. The Atures had formerly lived near the Maypures, but had become extinct, and the last family had disappeared about 1767. This was upwards of forty years prior to Humboldt's visit.

As a general rule the parrots lay their eggs and rear their young in the hollow of a tree. Among the exceptions may be mentioned *Bolborhynchus monachus*, which constructs a rude kind of nest; and *Pezoporus formosus*, which digs a hole in the ground and lays its eggs therein. A few species nidificate in holes, in cliffs, or river banks. In accordance with the general habits, the great majority of breeding-places are in the thickest woods, where hollow, time-eaten trees abound; and hence they are generally met with in secluded unfrequented localities. *Palæornis torquatus*, however, rather delights in the vicinity of towns and dwellings; it will nest not only in the gardens of the most thickly populated provinces, but even in the cavernous retreats of old pagodas.

The eggs are remarkably uniform in character. They are rarely, if ever, spotted or marked in any way; their form being from oval to egg-shaped; those of *Conurus*, *Psittacula*, *Trichoglossus*, and *Lorius* being oval, while those of *Arara*, *Platycercus*, *Psittacus*, *Cacatua*, and *Strigops*, are egg-shaped. The shell is finely granular, irregularly porous, smooth, and without lustre. The number of eggs laid by each female varies from 2 to 10. The nest of *Bolborhynchus monachus* frequently contains more than 10; but in this case it is known that several individuals lay their eggs in the same nest. The large species generally lay fewer eggs than the small. The *Strigops*, and several species of *Plyctolophus*, *Calyptorhynchus*, &c., have two or three eggs; most species of *Platycercus* have from 4 to 7, while *P. eximius* has as many as 10. Little is known about the time the eggs require to hatch; but it appears to be about 24 or 25 days. The young are blind and naked on leaving the egg, and are as helpless as most of the young of the *Scansores*. The head is at first large and heavy. In a very short time a long soft down is developed; and on the third day the first short feathers appear; on the sixth the eyes are opened; and on the 33rd the young are generally able to stand, and crawl about the hole. These observations apply more particularly to *Melopsittacus*. The first eggs are laid at a very early age: thus Dr. Rey has mentioned an instance in which *Melopsittacus undulatus* began to breed in its fifth month. The larger species attain a greater age before beginning to breed, and may not do so before they have entered on their second year.

Parrots occur on all the continental areas. The species are most abundant along a band comprising a few degrees on either side of the equator; and they preponderate more, and reach higher latitudes in the southern than in the northern hemisphere. Full details on the geographical distribution will be found in Otto Finsch's work; and a good general view may be gathered from an inspection of the maps given by him. The most widely distributed of the five families is *Psittacidæ*. Its representatives occur in America from about 30° S. lat. to about 22° N. lat. In Africa the range is from about 23° S. lat. to about 18° N. lat.; and in the East Indian Archipelago it occurs on nearly all the islands north of Australia, extending as far north in the Malay Peninsula and India as about 21° N. lat. The next most widely distributed family is the *Sittacidæ*. It ranges continuously from New Zealand, through Australia and the Indian Archipelago, to India and the southern slopes of the Himalayan Mountains. As yet, no parrots of this family have been found anywhere between India and the Red Sea; but to the east of the Red Sea, *Palæornis torquatus* is met with along a narrow strip of country right across the widest part of Africa. The *Trichoglossidæ* range over the Australian region from New Zealand to Celebes and the neighbouring islands. Further particulars on this part of our subject will be given presently. The *Plyctolophidæ* occur over very nearly the same area as the *Trichoglossidæ*. The *Strigopidæ* is the most restricted family, not having been seen beyond the New Zealand group of islands. This group has long been considered as a family in the order *Scansores*, but of late years there has been a tendency among ornithologists to accept a somewhat different position. Thus, Prince Lucien Bonaparte, in his 'Conspectus Avium,' 1858, raises it to the rank of an order (*Psittaci*), and places it before all the other orders, even before the *Accipitres*, which have so long stood at the head of our ornithological classifications. He recognises four families, viz., *Psittacidæ*, *Microglossidæ*, *Trichoglossidæ*, and *Strigopidæ*, which comprise in all about 300 species. Wallace (in 1864) also gives it an ordinal rank, and expresses his classificatory views in the following terms:—"The skull of a parrot is remarkable for its large size, for the nearly complete orbits, for the broad and powerful lower mandible, for the large and complicated lingual and hyoid bones, and for perfect articulation of the upper mandible to the cranium, peculiarities which, in their combination, separate it most widely from every other form of bird. The sternum has a characteristic form unlike that of any bird; the furculum is small, and attached lower down on the anterior margin of the keel, and in some genera is liable to be totally wanting in certain species. When present, however, it is of a semi-oval form, the two branches being connected in an unbroken curve without angles or projecting processes. The prehensile feet of parrots are used in a manner quite peculiar; for though other birds may secure their food with their foot while eating, no others in the whole class use it systematically as a hand to grasp and convey food to the mouth. We may fairly say they are the only birds that have hands, and use them as such; and this will serve to confirm the superiority which their large brain and highly organised cranium confers upon them. The presence of a prehensile foot, their uniformly fruit-eating habits, their wide distribution, their numerous modifications of form, and their utter dissimilarity to all other birds, added to the differences already pointed out in structure and habits, induce me to adopt without any hesitation the views of Bonaparte and Blyth, and to consider the parrots as one of the primary divisions or orders in the class of birds. In dividing this order into families, I follow generally Bonaparte and

Blainville, with a few modifications for simplicity. The great central mass of the order are the *Psittacidæ*, or true parrots, comprising all the American, and more than one-half the Old-World species. These must be divided into several sub-families, the *Palæornithinæ*, the *Psittacinæ*, and the *Eclectinæ*, containing the Indian and Malayan species. The next family, the *Platycercidæ* (the broad tails and ground parrots) are somewhat allied to the last group through the *Palæornithinæ*. They have different habits from most other parrots, being often terrestrial and seed eaters; their whole structure is weak, their flight slow and cuckoo-like; the keel of the sternum is lower and more rounded anteriorly than in the other families; the pelvis is short, broad, and flat; the skull is small; the bill short; the lower mandible broad and swollen; the legs rather long and slender; and the plumage lax and abundant. The *Plyctolophidæ*, or cockatoos, are distinguished by their powerful bills, crested heads, heavy form, and lax powdery plumage. They have a general resemblance to the last family, and also to the true *Psittacidæ*. The *Trichoglossidæ* are the best marked, and most specialised group of all. The whole head, as well as the bill, is elongated and compressed; the wings long and powerful; the feet strongly grasping; and the tongue always furnished with brush-like papillæ. They are connected with the *Psittacidæ* by means of *Loriculus*, which agrees with them in general structure, but has the ordinary smooth tongue. In order to bring these families into a natural sequence, I arrange them in the following order:—1. *Plyctolophidæ*; 2. *Platycercidæ*; 3. *Psittacidæ*; 4. *Trichoglossidæ*. The 5th family, *Strigopidæ*, containing the New Zealand owl-parrots, seems allied to the *Platycercidæ*, and should follow them in a general arrangement of the order."

Mr. Parker, in his account of the osteology of *Microglossus alecto*, appears to hold somewhat similar views, as he says this parrot is the most perfectly antithetical to the *Struthionidæ* of all the feathered tribes. If intelligence is to be the character of primary importance, the highest place should be given to the *Passeres* proper; if powerful flight and brute strength, then the eagles and falcons should rank highest. "But," he remarks, "there are qualities, dear to the morphologist, in which the parrots have the pre-eminence, and stand higher as birds than all other birds; and although, all things considered, the crow is the best type and model with which to compare the whole plumy brotherhood, yet in many things the parrot is a bird of birds; he is an ultra-type, and sets bounds to the class to which he belongs. But this bird, with the wise and solemn face of an elephant, has, like us, its chief and best qualities resident in the head; and if the skull of an ostrich be compared with that of the most psittacine of the parrots, the difference will appear almost as great as exists between a larva and an imago."

The latest monographer of the group, Otto Finsch, maintains the old view that the parrots form a family amongst the *Insessores*, and opposes the new one mentioned above.

The geographical distribution of the parrots presents some very peculiar features, as has been well shown by Mr. Wallace. He estimates that there are 368 species, which are thus distributed amongst the zoological regions established by Dr. Sclater:—

Region.	Species.	Genera.	Families.
Palæarctic . .	0	0	0
Nearctic . . .	1	1	1
Neotropical .	150	9	1
Ethiopian . .	25	4	1
Indian . . .	25	3	1
Australian . .	165	25	5

The Australian region is richer in species, genera, and families than any other; and in genera and families than all the others put together. The *Psittacidæ* occur in all the regions, but it is the only family represented in the non-Australian regions. Hence it will be seen there are no less than four out of the five families restricted to the Australian region. But the principal headquarters of this group are still more restricted. The Australian region itself is separable into three sub-regions, viz., Australia, the Pacific Islands, and the Austro-Malayan group. Each subregion has its peculiar features. In Australia the *Platycercidæ* and *Plyctolophidæ* are abundant; *Trichoglossidæ* comparatively rare; and *Psittacidæ* absent. In the Pacific Islands *Corophilus*, *Nestor*, and *Strigopidæ* are peculiar; *Platycercidæ* not abundant: and *Plyctolophidæ* wanting. In the Austro-Malayan sub-region the Lories are peculiar; the *Plyctolophidæ* abundant; the *Platycercidæ* less abundant; and the *Psittacidæ* are represented by several peculiar genera. The last-mentioned sub-region surpasses all the others in the number of the families, genera, and species which are found in it, as shown in the following table:—

	Families.	Genera.	Species.
Austro-Malayan Islands . .	4	16	86
Australia	3	10	60
Pacific Islands	3	4	30

From the great preponderance of forms in the Austro-Malayan islands, Mr. Wallace suspects the parrots were at one time restricted within this area, and that they have been dispersed from it as from a centre.

The *Trichoglossidæ* are considered to be the most highly organised parrots. It contains six genera, of which four are confined to the Austro-Malayan sub-region, while the others are spread over the remainder of the Australian region. Of the four Austro-Malayan genera three are remarkable for their ground colour being a vivid red, and for having very little green, which is the prevailing tint amongst the *Psittacidæ*; they constitute the sub-family *Loriinæ*, and are best represented by *Eos rubra* and *Eos cardinalis*. The Lories are confined to a long tract extending from the Moluccas on the west to the Solomon Islands on the east, and having New Guinea as the centrepiece. This area Mr. Wallace calls the Loriine region, and he has the following remarks upon it. "If we look at the area marked out upon a map (as shown in Proc. Zool. Soc. for 1864), we must be at once impressed with the idea that we have here roughly indicated the much greater extent at a recent period of the large island of New Guinea, the north-western portion of which seems even now to be undergoing a still further segmentation. This idea receives confirmation from the fact that almost every bird found in this area has its closest allies in New Guinea; and as we approach the central mass the variety of forms becomes greater. The genera *Monarcha* and *Mimeta* here have their maximum development; and *Tanysiptera*, as abnormal among kingfishers as Lories are among parrots, has almost exactly the same limits of distribution as they have. Within these limits are found some of the most curious forms of parrots, the giant black cockatoo (*Microglossus*) and the dwarf of the whole order (*Nasiterna*), the bare-headed *Dasyptilus* and the elegant little *Charmosyna*. *Tanygnathus* has the range of *Eos*, but extends north-westward to Celebes and the Philippines; *Geoffroyus* south-westward to Timor and Flores; while the remarkable genus *Eclectus* has exactly the same range as the Lories, whose attire it seems to mimic, for in it alone are found parrots whose only colour is red, with a portion of blue or black. This coincidence of the range of the red *Psittacidæ* with that of the red *Trichoglossidæ* is a very curious fact, and clearly intimates that these gay tints are not mere sports of nature, or designed for the delectation of man, but have a close connection with the life history of the creatures which they adorn, and probably subserve an important though hidden object in the economy of these groups." The Loriine region has yielded fifty-four species belonging to fifteen genera, and eight of the genera have not been found elsewhere. Australia has ten genera and sixty species, and six of the genera are peculiar to it. Australia has, however, been pretty well explored, whereas the central and most important part of the Loriine region has never been visited for scientific purposes. Hence it may be expected that the disparity between the two regions will be still more in favour of the Loriine. Wallace considers New Guinea as the still existing portion of what was once a great tropical Pacific continent; and that the crimson Lories, the black *Microglossus*, the Birds of Paradise, and the great Crowned Pigeons are but "a remnant and a sample of the strange and beautiful forms of life that once inhabited it, and many of which may still remain to be discovered in the untrodden Papuan forests."

Among the *Psittacidæ* the distribution of *Prioniturus* is especially dwelt upon by Mr. Wallace. It is the only genus in the order which has a spatulate tail, like that of the mot-mot. There are four species known, and these are equally divided between the Celebes and the Philippines. A similarly restricted range occurs in the genus *Cynopithecus* among the mammalia. These two groups of islands are situated on opposite sides of the line which separates the Indo-Malayan sub-region from the Austro-Malayan; but facts such as those cited indicate that these islands once had a closer connection than now. After describing the differences in the faunas of the two groups of islands, the author further adds: "The great islands which form the western half of the Archipelago, Borneo, Sumatra, Java, and the Malay peninsula, present a most surprising poverty of psittacine birds: only four species are found over this immense region, and these belong to three genera, of which only one is found on both sides of the boundary line. This fact forms one of the strongest proofs of the division of the Archipelago between the Indian and Australian regions; for on the one side we have fifteen genera, of which ten are quite peculiar, on the other three genera, of which one is Indian, one Indo-Australian, and one somewhat isolated species only peculiar. The distribution of the genus *Loriculus*, which is the only one really common to the Indian and Australian regions, is very interesting. The southern island of the Philippines seems to be its metropolis, since no less than four species are found there. One inhabits Celebes, one Sulla, and one Gilolo; the rest are found in Flores, Java, Sumatra, and Malacca, Ceylon, India, China, and Manilla. The range of the genus is therefore very extensive; yet one half of the species will be found concentrated in a limited tract, including Mindanao, North Celebes, Sulla, and Gilolo. This district is upon the confines of the Australian and the Indian regions; and it is very interesting to remark that this, the only genus which is common to the two, is of doubtful affinity, and serves to connect the pre-eminently Australian *Trichoglossidæ* with the *Psittacidæ* of the rest of the world." Mr. Wallace gives full details of the geographical distribution of all the species found in the Austro-Malayan sub-region, and the following is a summary of his list:—

Family I. PLYCTOLOPHIDÆ: *Cacatua*, 11 sp.; *Microglossus*, 2 sp.; *Nasiterna*, 1 sp.: making in all 3 genera and 14 species.

Family II. PLATYCERCIDÆ: *Platycercus*, 4 species.

Family III. PSITTACIDÆ: *Palæornis*, 3 sp.; *Psittinus*, 1 sp.; *Geoffroyus*, 4 sp.; *Prioniturus*, 4 sp.; *Cyclopsitta*, 6 sp.; *Tanygnathus*, 5 sp.; *Eclectus*, 8 sp.; *Dasyptilus*, 1 sp.; *Loriculus*, 11 sp.: or altogether 9 genera and 43 species.

Family IV. TRICHOGLOSSIDÆ: *Lorius*, 6 sp.; *Chalcopsitta*, 3 sp.; *Eos*, 9 sp.; *Trichoglossus*, 9 sp.; *Charmosyna*, 4 sp.: or in all 5 genera and 31 species.

Notes on all the Indian species are given by Mr. Jerdon in his "Birds of India." He describes seven species, of which six belong to *Palæornis* and one to *Loriculus*. We quote his accounts of the habits of *P. Alexandri* and *P. torquatus*:—"The Alexandrine parrakeet is found in the Lower Himalayas, in the forests of Malabar, also in the hilly regions of Central India and the Northern Circars. It is occasionally found in parts of the Carnatic; but it is not till you get far north that it is at all common. It is by no means confined to hill regions, for I have found it breeding in a grove of trees in the Deccan, not far, however, from some low hills; and it often comes into the open country to feed, but generally returns at night to the hills or jungles. It is said to be the ordinary parrakeet of the Punjaub. . . . . . It feeds both on fruits and grain, and sometimes returns great distances to roost in trees near the hills. At such times it flies at a great height. The call of this species is full and rich. It breeds in the cold weather, December and January, in holes of trees, and lays usually four white eggs." "The Rose-winged Parrakeet (*P. torquatus*) is found over all India, from the foot of the Himalayas to the extreme south and Ceylon, but it is rare to the east of the Bay of Bengal. It is found in other parts of Western Asia and throughout tropical Africa. It is one of the most common and familiar birds in India, frequenting cultivated ground and gardens, even in the barest and least wooded parts of the country, and it is habitually found about towns and villages, constantly perching on the house-top. It is very destructive to most kinds of grain as well as to fruit gardens. Burgess says that they carry off the ears of corn to trees to devour at leisure, and I have observed the same sometimes. When the grains are cut and housed, it feeds, on the ground, on the stubble cornfields, also on meadows, picking up what seeds it can, and now and then takes long flights hunting for any tree that may be in fruit, skimming close to and examining every tree; and when it has made a discovery of one in fruit, circling round, and sailing with outspread and down-pointing wings till it alights on the tree. It associates in flocks of various sizes, sometimes in vast numbers, and generally some hundreds roost together in some garden or grove. Mr. Layard has given an interesting account of the roosting of this species in Ceylon. At Saugor all the parrakeets, mynas, crows, bee-eaters, &c., of the neighbourhood, for some miles around, roost in company in a large grove of bamboos; and the deafening noise heard there from before sunset till dark, and from the first dawn of day till long after sunrise, give to the listener an idea of numberless noisy steam-engines at work. Many of the flocks of parrots are very late in returning, and fly along quite low, skimming the ground, and just rising over a tree, house, or any obstacle in the way, and, for several nights in succession, several parrakeets flew against the wall of a house on the top of a hill in Saugor, and were killed. It breeds both in holes in trees and, very commonly in the south of India, about houses, in holes in old buildings, tombs, &c. Like the last, it lays four white eggs. Its breeding season is from January to March. Adams states that he has seen this parrakeet pillage the nest of the Sandmartin; but with what intent he does not guess at. Its ordinary flight is rapid, with repeated strokes of the wing, sometimes wavy, laterally, or arrowy. It has a harsh cry, which it always repeats when in flight, as well as at other times. Mr. Philipps remarks that the kite will sometimes swoop down on them when perched on a tree, and carry one off in its talons; also that owls attack these birds by night."

In Gould's "Handbook to the Birds of Australia," 64 species are described. The most remarkable of them is, perhaps, the *Strigops habroptilus*, or Kakapo of New Zealand. He has collected together most of the accounts, which, lengthy as they are, we take in entirety.

Long before 1845, when a skin of this extraordinary parrot was for the first time sent to Europe, we had conclusive evidence of the existence of the species from the circumstance of plumes made of its feathers being worn by the Maories. It is somewhat strange, however, that such a lengthened period should have elapsed after the discovery and possession of New Zealand before so singular a bird should have found its way to Europe. At no very distant date it doubtless inhabited alike all the islands of the New Zealand group; but it probably no longer exists in the northern island, its extirpation thence being doubtless attributable to a variety of causes; it is that portion of the country in which the natives have chiefly resided, and the introduction since the visit of the celebrated navigator, Cook, of the pig, the dog, the cat, and that universal pest, the brown or Norway rat, has doubtless tended greatly to produce such a result, for these animals having now become wild, we may reasonably infer that they have played no inconsiderable part in the destruction not only of this comparatively helpless bird, but of many others; the time is probably not far distant when these marauders will obtain a footing in the middle and southern islands, the result of which may be anticipated by what has already occurred. The first published account of this singular bird is that given by Dr. Lyall, R.N., in the "Proceedings of the Zoological Society of London" for 1852, which I here transcribe:—"Although the Kakapo is said to be still found occasionally on some parts of the high mountains in the interior of the north island of New Zealand, the only place where we met with it, during our circumnavigation and exploration of the coasts of the islands in H.M.S. Acheron, was at the S.W. end of the middle island. There, in the deep sounds which intersect that part of the island, it is still found in considerable numbers inhabiting the dry spurs of hills or flats near the banks of rivers, where the trees are high and the forest comparatively free from fern or underwood. The first place where it was obtained was on a hill nearly 4000 feet above the level of the sea. It was also found living in communities on flats near the mouth of the rivers close to the sea. In these places its tracks resembled footpaths made by men, and led us at first to imagine that there must be natives in the neighbourhood. These tracks were about a foot wide, regularly pressed on the edges, which are two or three inches deep among the moss, and cross each other usually at right angles. The kakapo lives in holes under the roots of trees, and is also occasionally found under shelving rocks. The roots of many New Zealand trees growing partly above ground, holes are common under them; but where the kakapo is found, many of the holes appear to have been enlarged, although no earth was ever found thrown out near them. There were frequently two openings to these holes, and occasionally, though rarely, the trees over them were hollow for some distance up. The only occasion on which the kakapo was seen to fly was, when it got up one of these hollow trees, and was driven to an exit higher up. The flight was very short, the wings being scarcely moved, and the bird alighted on a tree at a lower level than the place from whence it had come, but soon got higher up by climbing, using its tail to assist it. Except when driven from its hole, the kakapo is never seen during the day, and it was only by the assistance of dogs that we were enabled to find it. Before dogs became common, and when the bird was plentiful in the inhabited parts of the island, the natives were in the habit of catching it at night, using torches to confuse it. It offers a formidable resistance to a dog, and sometimes inflicts severe wounds with its powerful claws and beak. At a very recent period it was common all over the west coast of the middle island, but there is now a race of wild dogs said to have overrun all the northern part of the shore, and to have almost extirpated the kakapos, wherever they have reached. Their range is said to be at present confined by a river or some such physical obstruction, and it is to be feared that if once they succeeded in gaining the stronghold of the kakapo (the south-west end of the island), the bird may soon become extinct. During the latter half of February, and the first half of March, while we were amongst the haunts of these birds, we found young ones in many of the holes, frequently only one, never more than two in the same hole. In the same hole where there were two young ones, I found also an addled egg. There was usually, but not always, an old bird in the same hole with the young ones. They build no nest, but simply make a slight hollow amongst the dry dust formed of decayed wood. The young were of different ages, some being nearly fully fledged, and others covered only with down. The egg is white and about the size of a pigeon's, two inches and an eighth long, by one inch and nine-sixteenths broad. The cry of the kakapo is a hoarse croak, varied occasionally by a discordant shriek when irritated or hungry. The Maories say that during winter they assemble together in large numbers in caves, and at the time of meeting, and again before dispersing to their summer haunts, that the noise they make is perfectly deafening. A good many young ones were brought on board the ship alive. Most of them died a few days afterwards, probably from want of sufficient care; some died after being kept a month or two, and the legs of others became deformed after they had been a few weeks in captivity. The cause of the deformity was supposed to be the want of proper food, and too close confinement. They were fed chiefly on soaked bread, oatmeal, and water and boiled potatoes. When let loose in a garden they would eat lettuces, cabbages, and grass, and would taste almost every green leaf that they came across. One, which I brought within six hundred miles of England (when it was accidentally killed), whilst at Sydney, ate eagerly of the leaves of a *Banksia*, and several species of *Eucalyptus*, as well as grass, appearing to prefer them all to its usual diet of bread and water. It was also very fond of nuts and almonds, and during the latter part of the homeward voyage, lived almost entirely on Brazilian ground-nuts. On several occasions the bird took sullen fits, during which it would eat nothing for two or three days at a time, screaming and defending itself with its beak when any one attempted to touch it. It was at all times of an uncertain temper; sometimes biting severely when such a thing was least expected. It appeared to be always in the best humour when first taken out of its box in the morning, hooking on eagerly with its upper mandible to the finger held down to lift it out. As soon as it was placed on the deck, it would attack the first object which attracted its attention, sometimes the leg of my trousers, sometimes a slipper or a boot. Of the latter it was particularly fond; it would nestle down upon it, flapping its wings, and showing every symptom of pleasure. It would then get up, rub against it with its sides, and roll upon it on its back, striking out with its feet whilst in this position. One of these birds, sent on shore by Capt. Stokes to the care of Major Murray, of the 65th regiment at Wellington, was allowed to run about his garden, where it was fond of the society of children, following them like a dog, wherever they went. Nearly all the adult kakapos which I skinned, were exceedingly fat, having a thick layer of oily fat or blubber on the breast, which it was very difficult to separate from the skin. Their stomach contained a pale green, sometimes almost white, homogeneous mass, without any trace of fibre in it. There can be little doubt but that their food consists partly of roots (their beaks are usually more or less covered with indurated mud), and partly of the leaves and tender shoots of various plants. At one place, where the birds were numerous, we observed that the young shoots of a leguminous shrub, growing by the bank of a river, were all nipped off, and this was said by our pilot, who had frequented these places for many years in a trading vessel, to be the work of the kakapo. Their flesh is white, and generally esteemed good eating."

In some letters to Mr. Gould from Sir George Grey, many of the above statements are confirmed, accompanied by additional ones. "The *Strigops* is called *Kakapo*, or night-kaka, by the aborigines of New Zealand, from the nocturnal habits of the bird. During the day, it remained hid in holes under the roots of trees or rocks; or very rarely, perched on the boughs of trees with a very dense thick foliage; at these times it appears stupid from its profound sleep, and if disturbed or taken from its hole immediately runs and tries to hide itself again, delighting, if practicable, to cover itself in a heap of soft dry grass; about sunset it becomes lively, animated, and playful, comes forth from its retreat and feeds on grass, weeds, vegetables, fruits, seeds, and roots; when eating grass it rather grazes than feeds, nibbling the grass in the manner of a rabbit or wombat. It sometimes climbs trees, but generally remains upon the ground, and only uses its short wings for the purpose of aiding its progress when running, balancing itself when on a tree or in making a short descent, half jump, half flight, from a higher to a lower bough. When feeding, if pleased with its food, it makes a continued grunting noise; it is a greedy bird and choice in its food, showing an evident relish for anything of which it is fond. It cries repeatedly during the night with a noise not very unlike that of the kaka, but not so loud. The kakapo is a very clever and intelligent bird, in fact, singularly so; contracts a strong affection for those who are kind to it, shows its attachment by climbing about and rubbing itself against its friend, and is eminently a social and playful bird; indeed, were it not for its dirty habits, it makes a far better pet than any other bird with which I am acquainted, for its manner of showing its attachment by playfulness and fondling, is more like that of a dog than a bird. It builds in holes under trees and rocks, and lays two or three white eggs, about the size of a pullet's, in the month of February; and the young birds are found in March. At present, 1854, the bird is known to exist only in the middle island of New Zealand, on the west coast, between Chalky Harbour and Jackson's Bay, and in the northern island about the sources of the Whangarie, and in part of the Taufa countries. It was within the recollection of the old people abundant in every part of New Zealand, and they say it has been exterminated by the cats introduced by Europeans, which are now found wild and in great numbers in every part ot the country; they say also that the large rat, introduced from Europe, has done its part in the work of destruction. The natives assert, that when the breeding season is over, the kakapo lives in societies of five or six in the same hole; and they also state that it is a provident bird, and lays up in the fine season a store of fern root for the bad weather. I have had five or six of these birds in captivity, but never succeeded in keeping them alive for more than eighteen months or two years. The last I had I sent home as a present to the Zoological Society, but I am informed it died off Cape Horn."

A later account has been drawn up by M. Julius Haast, and a translation of his notes is given in the "Ibis" for 1864, p. 340. Mr. Gould gives the following extracts:—"The principal resorts of the kakapo are the green plots in the open and mossy beech woods, near mountain streams and rocky declivities, beneath large moss-covered stones overgrown by beech roots; also the mossy banks of the large rivers which are occasionally flooded by a sudden thaw, or heavy rains. It is remarkable that it is never found on the eastern side of the Alps, though extensive beech forests occur there also; the only part excepted is the valley of the Makaoora river which forms the Wanaka lake. It appears, therefore, to be confined to the western slope of the principal mountain chain, and only to pass over the low and wooded defile that leads from the source of the Haast river to those of the Makaoora. Even here, however, it is not found beyond the mouth of the river near the Wanaka lake, as lower down there are no forests. The kakapo is very frequently met with in the valley of the last-named river, and in the Makaoora forest. In the Wilkin valley it is less numerous, and in the Hunter valley it is not to be met with. Until now, it has been supposed to be a night bird, but my observations convince me that this is not always the case. It is true that its call is mostly heard about an hour after sunset, at which time it commences to roam about where the thick foliage creates a kind of artificial darkness, but I have several times met with it in the daytime. On one occasion, as soon as the bird saw me it threw itself off the tree as if it were shot, and escaped under some large fragments of rock, without opening its wings, or using them in any way to break its fall. It is strange that a bird with well-formed wings should prefer to use its feet as a means of locomotion, especially when the feet seem rather formed, from the position of the toes, for climbing than for walking or running. To ascertain whether the kakapo would not fly, or at least flutter when pursued, I had a large specimen which had been captured by my dog without being injured, brought to an open place where there was sufficient space to open its wings while running; but instead of attempting to do so, the bird ran towards the nearest thicket, moving much like a fowl, with a celerity that, considering the position of its toes and its unwieldy form, greatly surprised me. Viewed sideways, the wings appeared to be closely pressed to the body, but from behind they were observed to be slightly open; more, apparently, for the purpose of preserving a right balance, than to aid it in running." Dr. Haast also refers to its vegetable diet. Individuals sometimes so stuff themselves with moss that they become greatly distended. It dwells in clefts, fissures, and amongst roots; and frequently proves a formidable opponent to a dog. Mr. Gray's description of the species is:—"Upper surface sap green, with a verdigris tinge on the wings, each feather marked in the middle with yellow, which is margined on the sides with black, from which spring irregular transverse bands of the same colour, the outer webs of the greater wing-coverts, quills, secondaries, and entire tail brownish buff, irregularly banded transversely with black; between every alternate set lemon yellow; the inner webs of quills and secondaries black, more or less transversely banded with lemon yellow; under surface pale greenish yellow, tinged with lemon yellow, more or less marked along the shaft with pale yellow, which is narrowly margined with brownish black; some of the feathers have transverse bands of the same colour; the top of the head brownish black; margined outerly with sap green, tinged in some places with verdigris, and marked in the middle with pale yellow: the front cheeks, ear coverts, and the projecting feathers of the face pale amber, marked in the middle with yellowish white; bill white; feet plumbeous black. Length two feet four inches.

In addition to the living species there are a few known which have probably become extinct within the last few centuries. The only witnesses we have that they once existed are a few osseous fragments, the reports of early voyagers, and the traditions preserved by the native population. The *Psittacus mauritianus* is one example. All that we possess of it is a lower mandible. It was found in the soil of the "Mare aux Songe," or Arum Marsh, near Mahebourg, in the island of Mauritius, under the circumstances mentioned under Dodo, E.C.S. This fragment belonged to a bird as large as the larger maccaws; and formed part of a jaw possessed of great mechanical and muscular strength. It has been carefully examined and compared by Milne-Edwards with the same part in other parrots; and the result of his labours will be found fully detailed in the "Annales des Sciences Naturelles" for 1866. He finds that this part of the skeleton is in itself sufficiently distinctive to enable us to assign any lower jaw to its genus or subgenus, but that further evidence is needed to be confident as to the species. Considering this to be the case, he believes that some confidence may be placed on the conclusion drawn from the lower mandible only of the extinct species. It had been suggested by Mr. G. R. Gray, that *P. mauritianus* may be the same as the *Mascarinus obscurus* figured by Levaillant, which species formerly lived in Mauritius, but is only known by a few museum specimens and some figures. Milne-Edwards compared the lower mandibles of the two species, and finds they are widely different, so much so that they cannot be placed in the same genus. *P. mauritianus* approaches *Coracopsis vasa* of Madagascar in size; but the form of its mandible is very different. In the size and form of the mandible it rather resembles the large maccaws of South America; nevertheless there are several important differences even from these, as also from the species of *Microglossus*. It appears to represent in the Mascarene islands the *Ara* of South America in the same way as *Microglossus* and *Calyptorhynchus* represent the same type in the Australian regions. There is, however, more analogy between the forms of South America and South Africa than between those of South Africa and Australia. His main conclusion then is, that the Mauritius bird differs from other parrots by osteological characters of the same value as those by which the *Ara*, *Calyptorhynchus*, *Microglossus* are separated; and that they resemble *Ara* and *Microglossus* more than any other genus. No mention of this species has been found in old travels. Dubois describes in a very rough way all the parrots he saw or heard of in the Mascarene islands. Of the six species mentioned by him, five may be identified with more or less certainty as *Coracopsis vasa*, *Mascarinus obscurus*, the male and female of *Palæornis eques*, and *Psittacula cana*. The one which cannot be identified is said to be about the size of the pigeon, and therefore it cannot be *P. mauritianus*.

(O. Finsch, *Die Papageien*; J. Gould, *Handbook to the Birds of Australia*; T. C. Jerdon, *The Birds of India*; A. R. Wallace, *Proc. Zool. Soc.* for 1865, pp. 272—295; Milne-Edwards, *Annales des Sciences Naturelles*, 5th series, vol. vi. pp. 91—111; Prof. R. Owen, *Ibis* for 1866, p. 168; W. K. Parker, *Proc. Zool. Soc.* for 1865, pp. 235—238.)

PTILIUM, a genus of coleopterous insects, belonging to the family *Trichopterygidæ*. It comprises numerous British species, some of which have been discovered for the first time within the last few years.

PYRAMIDELLIDÆ [E. C. vol. iii. col. 510], a family which is abundantly represented on the British shores, and which includes a vast host of minute shells scattered all over the world. Like some other families, its limits have been variously defined, and much contrariety of opinion prevails as to what genera do or do not belong to it. So difficult is it to make conformable descriptions of genera and family that it not unfrequently happens that a genus possesses one or more characters which is not assigned to the family in the definition. This seems to be due, not from oversight on the part of the authors, but to the difficulty of framing the definitions. The genus *Aclis* affords one illustration. Originally its species was assigned to *Turbo*, then to *Turritella*, next to *Chemnitzia*, afterwards to *Aclis*. But it does not seem that malacologists intend to leave them there, for they have latterly been transferred to *Rissoa*. Adams considers it to form four distinct genera, namely, *Aclis*, *Hyala* (H. and A. Adams), *Ebala*, Gray; and *Dunkeria*, Carpenter. Mr. Jeffreys also recognises the heterogeneity of the genus *Aclis*, and proposes to separate *A. unica* as the type of a genus named *Graphis*, which species was previously made the type of *Hyala*; and *A. Gulsonæ* as the type of another genus to be named *Menippe*. *Odostomia* is another example of the uncertainty of classificatory views, as will be seen from the following history of the name by Mr. Jeffreys:—"In the Supplement to the 4th, 5th, and 6th editions of the 'Encyclopædia Britannica' (published at intervals between 1818 and 1824) will be found the article 'Conchology,' by Dr. Fleming. The genus *Odostomia* is there described as consisting of certain species of marine shells, placed by British writers in the genus *Turbo*, in which the columella is furnished with folds. The *Turbo interstincta*, *unidentata*, *plicata*, *Sandivicensis*, and *insculpta* of Montagu are of this genus. The article was separately re-published with plates in 1837. Fleming's 'Philosophy of Zoology' (1822) enumerates *Odostomia* as one of the genera of the marine *Turbonidæ*; and it is, therefore, probable that the number of the Encyclopædia which contained the article 'Conchology' had then appeared. In 1826 Risso (Hist. Nat. l'Eur. Mérid. vol. iv. p. 224) formed the genus *Turbonilla*, on the MS. authority of Leach, for three fossil species; all are described as longitudinally ribbed, and one of them furnished with a fold. In Turton's 'Enumeration of Marine Shells found on the Devonshire Coast' (1829), *Odontostoma* was proposed by him as the generic name, and is thus characterised: 'Shell conic, oval; pillar with a single tooth or fold towards the middle; operculum none. Includes *Turbo unidentatus* and others.' This description, in respect of the absence of an operculum is obviously wrong. Fleming's 'History of British Animals' (1828) gave a more correct definition of the present genus. The 7th volume of the 'Edinburgh Encyclopædia (1830), under the head 'Conchology,' has full descriptions of the genus *Odostomia* and of the abovenamed species of Montagu; but *Pupa* and other land species are by some mistake confounded with them. Alcide D'Orbigny's account of the Mollusca, in the Supplement to Barker-Webb and Berthelot's 'Natural History of the Canary Isles' (1839 or 1840), gives *Chemnitzia* as a sub-genus of *Melania*; it is inadequately defined, the animal being described as 'inconnu,' and the shell as intermediate between *Eulima* and *Bonellia* or *Niso*. The *Turbo elegantissimus* of Montagu (*T. lacteus*, L.) is the sole type of D'Orbigny's sub-genus. Much more precise and accurate was the definition by the Rev. R. T. Lowe in the 'Proceedings of the Zoological Society for 1840,' of his genus *Parthenia*, which corresponds with *Chemnitzia*. Three more synonyms are *Pyrgiscus*, Philippi ('Wiegman's Archiv.' 1841), *Orthostelis*, Aradas and Maggiore ('Atti Acad. Giœnia,' 1841), and *Loxonema*, Phillips ('Palæozoic Fossils of Cornwall,' 1841), to which may be added, in part, *Jaminea* of Brown (not of Leach or Risso), *Turbonella* of Leach; and for certain species, *Eulimella* of Forbes and *Auriculina* of Gray." Mr. Jeffreys collocates all the species usually assigned to *Chemnitzia* and *Eulimella* in the genus *Odostomia*. Some authors have a different tendency, and separate the species into a large number of genera. Without having made the group a special study, it is difficult to satisfy oneself as to the proper delineations of the collocations of species or the precise boundaries of the family. For the purpose of the present article we shall consider that the family embraces all the genera mentioned in the E. C. article, with the exception of *Truncatella* and *Otina*; and in order to show the variations and distinctions of the British members, we give the following analytical view of their characters, drawn up from Jeffrey's 'British Conchology.'

Body	spirally twisted	*Pyramidellidæ.*
„	slender	*Aclis.*
„	slender	*A. supranitida.*
„	usually slender	*Odostomia.*
„	spiral and ciliated	*Stilifer.*
„	spiral and smooth	*Eulima.*
Head	furnished with a long cylindrical and retractile proboscis	*Pyramidellidæ.*
„	terminating in an unarmed and suctorial mouth	*Stilifer.*
„	with a long, cylindrical and retractile proboscis	*Eulima.*
Flap or Snout,	extensile, but rarely projecting beyond the foot	*Pyramidellidæ.*
„	projecting beyond the foot	*Odostomia.*
„	carried just before the foot	*O. clavula.*
„	not always extended beyond the foot	*O. albella.*
„	a little in advance of the foot	*O. turrita.*
„	flexible and extensile	*O. plicata.*
„	considerably in advance of the foot when the animal is in active motion, scarcely extending to the front edge when at rest	*O. dolioliformis.*
„	extends from the tentacular membrane beyond the foot	*O. spiralis.*
„	extends from the tentacular membrane to a little beyond the foot, and forming a sort of head veil	*O. rufa.*
„	carried before the foot when on the march	*O. lactea.*
„	lies between the tentacles and foot	*Stilifer Turtoni.*
„	not much extended	*Eulima polita.*
„	projects beyond the foot	*E. distorta.*
„	flexible, and projects a little beyond the foot	*E. stenostoma.*
„	seldom projecting beyond the foot	*E. bilineata.*
Tentacles,	conical or triangular, flattened and smooth, with more or less inflated tips	*Pyramidellidæ.*
„	long, approximating at their bases	*Aclis.*
„	moderately long, flat, rounded or obtuse at the tips, quite smooth, even under high magnifying powers, and divergent	*A. unica.*
„	cylindrical, slender, somewhat inflated at the top, close together at the base	*A. supranitida.*
„	thick, broad, short, not very membranous, rounded at the tips, each of which has a minute flake-white lobe or inflation; they are united by an intermediate membrane	*A. Gulsonæ.*
„	triangular and folded inwards (not unlike an ass's ears), united at their base by an intermediate membrane	*Odostomia.*
„	extraordinarily short and broad, mutually connected in front and vibrating very actively, swelling out behind like a minute leaf; they are not divergent, but borne straight and close together; each terminating in two white inflations, viz., one quite apical and the other immediately below it, both being semi-circular, and as if soldered to the external sides of the points or tips	*O. clavula.*
„	leaf-like, rather short and thick	*O. albella.*
„	bevelled and pointed like an awl; each also has a yellow longitudinal line; tips inflated and white	*O. pallida.*
„	flat, bevelled, not very short; tips moderately large, rounded, inflated and flake white	*O. conoidea.*
Tentacles	moderately long and divergent; each has a flake-white longitudinal line in the middle running from base to point; edges slightly folded; tips less white and inflated than in allied species	*O. acuta.*
„	broad, short, awl-shaped, setose (?), blunt, with a fine transparent line down the middle of each	*O. unidentata.*
„	rather long and leaf-like, with blunt tips	*O. turrita.*
„	leaf-like, and presenting three equal-sized, angular and flattened sides, which are folded a little inwards; tips rounded but not much inflated	*O. plicata.*
„	coalescing at their bases, very broad and short; tips very small, white, and slightly inflated	*O. insculpta.*
„	strong, rather long, without much auriform folding, rounded and taper, terminating in minute circular snow-white inflated tips; instead of the tentacles moderately diverging on each side of the snout, they are widely curved and carried at a right angle to the axis of the shell	*O. diaphana.*
„	short, bevelled, not broad, tapering to a fine point, and having small white inflated tips; they are carried in front of the head with an angular divergence of about 75°	*O. obliqua.*
„	proportionally larger than in other species, not so triangular nor furnished with such broad lateral membranes, nor do they coalesce so decidedly as another species to form a veil	*O. dolioliformis.*
„	very short, not much folded, terminating in indistinct flake-white lobes; the lateral membranes, which are not so extensive as any other species, coalesce and form a shallow veil	*O. decussata.*
„	very short, united at their bases; their thin edges are unrolled on the march, which gives them a very large sub-triangular, broad, leafy aspect, instead of the usual ear-shaped figure; tips large and inflated	*O. indistincta.*
„	varying in length, rather broad, with a small white bulb on each tip; they are retractile as in *Rissoa*	*O. interstincta.*
„	united at the base in front, and widen by diverging; short, flat, and broad, setose (?), with a snow-white line from base to point, and a round flake-white dot at each of their tips	*O. spiralis.*
„	comparatively long and slender, united at the bases, and having very distinct white inflated tips	*O. fenestrata.*
„	rather long, strong, and divergent; they do not quite coalesce at their bases, being separated by a distinct groove, which is the continuation of one on the snout from the point where the notch ceases; terminal bulbs not much developed	*O. scalaris.*
„	short, broad, very little folded and diverging	*O. rufa.*
„	short, very bluntly pointed and leaf-like, having large and extremely flexible lateral membranes, which do not coalesce for half their height, and are capable of instantaneously assuming various shapes	*O. lactea.*

Tentacles marked with a paleish purple streak; when spread they have the lateral membranes united almost to the tips, which are minute and acutely pointed, so that the tentacles then appear like a single united leaf	*O. pusilla.*
„ short, often folded inwards, like a round and undeveloped leaf, protruded horizontally	*O. Scillæ.*
„ diverging almost at a right angle, and resembling short, broad, minute leaves, each marked with an opaque white stripe or vein through the middle, they bevel to a fine edge, and can, with their large flexible margins (like the tentacles of all other species of *Odostomia*) simulate ear-shaped folds; tips but slightly developed	*O. acicula.*
„ cylindrical	*Stilifer.*
„ club-shaped, somewhat compressed, thick and rather long, sometimes enlarged towards the tips (which are blunt), widely diverging, but united at their bases; they are more or less strangulated or constricted, usually at about one-fourth of the distance from their bases, the cilia with which they are covered seem to produce a circulating current	*S. Turtoni.*
„ awl-shaped, approximating at their bases	*Eulima.*
„ short, but slender and pointed, slightly diverging outwards; every part except the base is streaked lengthwise with golden yellow or orange, and the whole is covered with a transparent gelatinous sheath	*E. polita.*
„ cylindrical, rather short and diverging, with blunt tips	*E. intermedia.*
„ long and slender, placed close together at their origin, and diverging at an acute angle	*E. distorta.*
„ rather long and slender, with rounded tips: they diverge at an angle of about 25°; at the base of each is a patch of flake-white	*E. stenostoma.*
„ rather long	*E. bilineata.*
Eyes sessile at the inner base of the tentacles, and placed near to each other	*Pyramidellidæ.*
„ placed rather more on the outer than the inner base of the tentacles	*Aclis.*
„ large and black, not on peduncles or prominences, but fixed each on the centre of the base of either tentacle, with very little external inclination, and widely apart; on the march the eyes are usually carried within the margin of the shell	*A. unica.*
„ immersed at the base of the tentacles, and placed rather laterally	*A. supranitida.*
„ black, not very near together, immersed close to the base of the tentacles, on minute white circles	*A. Gulsonæ.*
„ immersed in the skin or outer integument, and placed on the neck a little behind the tentacles	*Odostomia.*
„ at the inner bases of the tentacles, not very close together	*O. clavula.*
„ small, placed close together	*O. albella.*
„ placed somewhat apart	*O. pallida.*
„ very black, situated exactly at the internal bases of the tentacles, immersed in the skin, so close to each other that a hair can scarcely be laid between them	*O. conoidea.*
„ rather close together in the centre behind the tentacles	*O. acuta.*
„ close together, sunken in the membrane which connects the tentacles	*O. unidentata.*

Eyes very small, placed close together on the middle of the neck, between the tentacles at their inner bases	*O. turrita.*
„ not quite so close together as in some other species, seated on the tentacles at their inner bases	*O. plicata.*
„ close together	*O. insculpta.*
„ close together, at the internal basal angles of the tentacles	*O. diaphana.*
„ close together, at the united internal bases of the tentacles	*O. obliqua.*
„ as usual	*O. dolioliformi*
„ very close together, exactly at the internal bases, not immersed, but a little elevated on minute prominences	*O. decussata.*
„ very black, conspicuous, and close together	*O. indistincta.*
„ small, rather close together, at the inner base of the tentacles, sometimes withdrawn under the shell when the animal is crawling	*O. interstincta*
„ large and black, placed behind the fork of the tentacles, on their internal angles	*O. spiralis.*
„ conspicuous, close together, and imbedded at the inner angles of the tentacles	*O. fenestrata.*
„ black, not very close together	*O. scalaris.*
„ placed on the inner bases of the tentacles	*O. rufa.*
„ at a little distance from the internal line of the tentacular bases	*O. lactea.*
„ small, black, placed close together behind the tentacles	*O. Scillæ.*
„ very black, not quite close together, and placed a little behind the inner bases of the tentacles	*O. acicula.*
„ sessile, placed on the neck behind the tentacles	*Stilifer.*
„ exceedingly small, placed at some distance behind the tentacles	*S. Turtoni.*
„ almost sessile, placed at the external bases of the tentacles, or nearly behind them on the neck	*Eulima.*
„ large, black, and round, placed close together on slight and minute eminences, each of which is encircled by a ring of golden yellow, on a level with the base of the tentacles; this part is seldom protruded, although the eyes are conspicuous through the shell	*E. polita.*
„ small and black, placed close together on short bulbs; they are always conspicuous; each is encircled by a dark orange disk	*E. intermedia*
„ black, placed on slight bulgings of the tentacles at their outer base	*E. distorta.*
„ small and black, persistent after death, when they are distinctly seen through the shell	*E. bilineata.*
Foot lanceolate, and double-edged in front	*Pyramidellid*
„ slender, greatly hollowed out in front, and deeply labiated, having distinct, long arched, linear auricles, which play or vibrate when the animal is crawling, beneath which it is slightly constricted; it terminates in a rounded, rather broad point; no median line is apparent in any part of the sole	*Aclis unica.*
„ having the upper edge somewhat detached, narrower than the sole, and extended	*A. supranitid*
„ exceedingly short, narrow, deeply bifurcated in front, rounded behind when at rest, and a little lengthened in action; the front edge is long, slender, grooved at the margin in front, and on each side, the upper and lower surfaces being entire	*A. Gulsonæ.*
„ flexible, more or less concave in front, with longish auricles, below which it is gradually constricted; the margins are	

thin, and often folded upwards; it is either bluntly or sharply pointed behind; when the animal is in motion there is on each side of the foot a marginal series of about eight very minute glossy points . . . . *Odostomia clavula.*

Foot short, squarish in front, narrowed or constricted in the middle, broader, and bluntly-pointed behind; sole edged with yellow. . . . . . . *O. albella.*

„ short, truncated, and slightly notched in front, where it is indistinctly auricled at each corner, terminating behind in an abrupt and short point . . . *O. pallida.*

„ large, rather long, membranous, generally reflected at the sides on itself (which reflexion it in some measure retains on the march), deeply arched in front, causing the flanks to be pointed and gradually tapering behind in a bluntly-angular point; sole slit in the middle in front . . . . *O. conoidea.*

„ short, of a more opaque white than the rest of the body; it is excavated in front, and so deeply divided or lobed as occasionally, when fully extended, to present the appearance of a second pair of short tentacles; it terminates behind in a more or less obtuse point . . . . *O. acuta.*

„ short, truncated in front, and slightly eared, sloping behind to a broad, obtuse, lance-shaped point; sole in front flake-white, behind hyaline, with a pure longitudinal line along the centre of the posterior half; it is divided from the upper disk by a shallow groove, giving the foot a labiated aspect . . *O. unidentata.*

„ rather broad, more or less indented (and now and then deeply bi-lobed) in front, obliquely truncated and irregularly bi-lobed behind . . . . . . *O. turrita.*

„ squarish in front, and bluntly-pointed behind; sole slightly grooved lengthwise on the posterior half . . . . *O. plicata.*

„ deeply notched in front, forming at each corner a divergent acute auricle, behind which it becomes a little constricted, and terminates in two symmetrical distinct pointed tails or streamers, which describe an angle of separation equal to that of the fore and middle fingers when placed as far apart as possible . . . . *O. insculpta.*

„ long, broad, and thin, rather concave in front, slightly auricled, and when fully extended reaching beyond the body whorl in front; it terminates in a distinct bifurcation, which is very apparent on a slow march, but on a quicker pace being attained the fork in some measure decreases, in consequence of the greater extension of the foot . . . . *O. diaphana.*

„ short, concave in front, slightly auricled, terminating obtusely behind . . *O. obliqua.*

„ apparently divided into two parts; the anterior or front portion is constricted, slender, attenuated, and very extensile, slightly auricled and notched, and nearly clear white; the posterior or hinder portion is somewhat oval, short, broad, fleshy, of an opaque pale drab, and divided in the middle by a deep longitudinal fissure or groove, that seems almost to separate this portion into two equal lobes, which terminate together in a rounded point, with a narrow central notch . . . . *O. dolioliformis.*

„ rather broad and truncated in front, without the usual ear-shaped points at the corners, becoming a little constricted behind, and having a very rounded extremity . . . . . . *O. decussata.*

Foot large, long, and extensile, thin, nearly transparent, either truncated or concave in front (depending on the will or action of the animal), with very large auricles, which in progression are used as feelers; the edges are often folded inwards; it ends in a needle point . *O. indistincta.*

„ short and narrowish, truncated or slightly indented in front, with small auricles, behind which it is constricted for about one-third of its length; tail bluntly pointed . . . . *O. interstincta.*

„ rather broad, slightly auricled, and sinuated on each side; sole slightly grooved lengthwise in the middle; tail rounded when the animal is at rest or at half stretch, and bluntly pointed in full march . . . . *O. spiralis.*

„ in slow march short, broad, and obtuse; but when the pace is accelerated it becomes attenuated and extends to the bottom of the penultimate whorl; it makes in front a concave sweep, ending on the right and left in very slight ear-shaped points; it has a somewhat lanceolate shape behind . . . . *O. fenestrata.*

„ short, slightly auricled, and bluntly pointed behind. . . . . *O. scalaris.*

„ large, moderately long, auricled in front, tapering behind to a point when at full stretch, but rounded when at rest . *O. rufa.*

„ truncated in front, very slightly auricled, narrow, not very long, attenuated, and tapering behind to a rounded broad termination. . . . . . . *O. lactea.*

„ much longer than in last species, extending on the march to the last whorl but two, and terminating in almost a needle point; whilst in the preceding species, under the same circumstances, it is quite rounded, and does not reach beyond the last or body whorl . . *O. pusilla.*

„ long and broad, truncated in front, with rather acute angles or corners, abruptly ending behind in a minute point or tail . . . . *O. Scillæ.*

„ long (often extending on the march to the antepenultimate whorl), and very thin, square in front, and expanding at the corners into rather sharp-pointed auricles, behind which it is gradually constricted towards the upper part of the body, and terminates in a narrow, slender, and acute point . . . *O. acicula.*

„ tongue-shaped, and partly tubular, with a slit in the sole . . . . . *Stilifer.*

„ elongated, in front bulbous, and forming a creeping disk, behind somewhat tubular and tapering to a fine point; the sole is slit backwards down the middle for more than three-fourths of its length, the opening or commencement of the slit being of an oval shape . . . *S. Turtoni.*

„ lanceolate, double-edged as well as truncated, and usually bi-lobed in front . *Eulima.*

„ small, and mostly short; squarish and broader in front, with angular corners or lobes edged with yellow, narrower towards the middle, and sharply rounded behind; the inner fold or groove formed by the front edge is closely lined with vibratory cilia in constant and rapid motion; sole flake white, slightly furrowed down the middle . . . . *E. polita.*

„ shortish, slightly cloven in front, and bluntly pointed behind, expanded towards the sides . . . . . *E. intermedia.*

Foot elongated, rounded in front, and bluntly pointed behind	*E. distorta.*
„ broad, squarish, and slightly bi-lobed in front, narrowing behind to a bluntly rounded point	*E. stenostoma.*
Branchial apparatus consisting of a single gill plume	*Pyramidellidæ.*
Branchial plume narrow and curved, consisting of about 15 to 18 rather coarse, opaque, pale drab strands	*Aclis Gulsonæ.*
„ single (?)	*Stilifer.*
„ single (?)	*Eulima.*
Tongue unarmed or toothless	*Pyramidellidæ.*
No denticulated tongue	*Stilifer.*
No tongue	*Eulima.*
Body clear white, with very minute and close-set flashy specks	*Aclis unica.*
„ entirely white	*A. supranitida.*
„ flake-white, with a faint tinge of yellow	*A. Gulsonæ.*
„ clear frosted white	*Odostomia clavula.*
„ cream colour, streaked with sulphur, sometimes clear white, gelatinous, and of a granular texture under a high magnifying power	*O. albella.*
„ white, covered with minute yellow specks	*O. pallida.*
„ clear bluish white throughout, with faint streaks of flake-white	*O. conoidea.*
„ dirty white, speckled with pale yellow, red, brown, or lead colour points, which are irregularly distributed over many of the external organs	*O. acuta.*
„ clear bluish white.	*O. unidentata.*
„ white, with a bluish tinge, covered with exceedingly minute granules, which give the surface, especially the foot, a frosted appearance	*O. turrita.*
„ whitish, with minute and close-set yellow specks	*O. plicata.*
„ opaque frosted white, with a rather large patch of dull claret-red on the back	*O. insculpta.*
„ brilliant frosted subhyaline white	*O. diaphana.*
„ clear white, with a slightly frosted appearance	*O. obliqua.*
„ hyaline, pale azure	*O. dolioliformis.*
„ clear white, except the head, which is pale pink or red	*O. decussata.*
„ nearly clear white, with a pale yellowish tinge, overspread or powdered with minute snow-white flakes or lemon-coloured points	*O. indistincta.*
„ white and transparent	*O. interstincta.*
„ clear white, delicately suffused with snow-white points of different sizes	*O. spiralis.*
„ nearly clear white, with a frosted aspect; the neck is marked on each side, as far as the tentacles, with a pale lead-coloured stripe of unequal breadth, which is composed of very minute points, so as to give the stripes a mottled look; a tinge of the same colour pervades the basal portion of the tentacles and upper surface of the foot	*O. fenestrata.*
„ nearly clear frosted white or pale red-brown	*O. scalaris.*
„ of a clear pale azure colour, irregularly aspersed with snow-white flakes	*O. rufa.*
„ clear white	*O. lactea.*
„ milk-white, microscopically speckled with flake-white	*O. Scillæ.*
„ nearly clear frosted white, mixed with minute snowy flakes	*O. acicula.*
„ white, and delicately stippled	*Stilifer Turtoni.*
„ whitish; front tinted with pale yellow, and more or less speckled with golden yellow or bright orange	*Eulima polita.*
„ milk white	*E. intermedia.*
„ whitish, mottled with reddish brown	*E. distorta.*
„ milk-white	*E. stenostoma.*
„ whitish, with a faint tinge of yellow.	*E. bilineata.*

Mantle furnished with a cylindrical filament at the upper angle of the mouth of the shell	*Aclis unica.*
„ even with the shell	*A. Gulsonæ.*
„ plain edged, somewhat folded, so as to form a slight canal	*Odostomia.*
„ folded at the upper angle of the mouth of the shell, so as to form a tubular canal	*O. acuta.*
„ having the usual fold at the upper angle of the aperture of the shell	*O. insculpta.*
„ forming a conspicuous tubular fold at the upper angle of the aperture of the shell	*O. diaphana.*
„ occasionally forming a small conduit or fold at the upper angle of the aperture of the shell	*O. obliqua.*
„ slightly channelled at the upper angle of the shell on the right side	*O. dolioliform*
„ having a small offset at the upper angle	*O. fenestrata.*
„ having a small cloven fold at the upper angle of the mouth of the shell	*O. scalaris.*
„ even, with hardly a trace of the usual branchial fold	*O. lactea.*
„ having the usual fold at the upper corner	*O. acicula.*
„ folded on the right side, so as to form a slight branchial canal, and spread over the base of the shell	*Stilifer.*
„ thickened at its edges; canal terminating in an oval or roundish hole	*S. Turtoni.*
„ having a rudimentary branchial fold	*Eulima.*
„ fleshy, with a plain margin, not reflected over any part of the shell	*E. polita.*
„ rather thin; edges even with the mouth of the shell	*E. intermedi*
„ thin, stippled with brown.	*E. stenostoma*
Neck very long, cylindrical, and finely wrinkled across; the vertical fissure of the mouth lies under the tentacular membrane	*Aclis Gulsona*
„ greatly protruded, showing on the mouth a canal or groove, bounded by two parallel longitudinal lines	*Odostomia cl vula.*
Opercular lobe simple	*Aclis unica.*
„ ample, of a different shape on each side, being on the right large, and forming three or four folds, on the left produced into a single rounded lobe, which is folded behind	*A. supranitid*
„ plain	*A. Gulsonæ.*
„ simple	*Odostomia d cussata.*
„ simple and obscure	*O. indistincta*
„ obscure	*O. lactea.*
Shell small, conically pyramidal	*Pyramidellid*
„ elongated	*Aclis.*
„ needle-shaped, thin, semi-transparent, somewhat glossy	*A. unica.*
„ forming an elongated and slender cone, rather solid for its size, semi-transparent, and somewhat glossy	*A. ascaris.*
„ ten times larger than in *A. ascaris*, and otherwise differing therefrom, in not being so slender, and in having a much broader base	*A. supranitid*
„ forming an elongated cone, very thin, transparent, and lustrous	*A. Walleri.*
„ slender, rather cylindrical than conical, very thin, transparent, and lustrous	*A. Gulsonæ.*
„ forming a cone of various lengths	*Odostomia.*
„ forming an oblong cone, very thin, transparent, and lustrous	*O. minima.*
„ forming a cylindrical cone, not very thin, transparent and glossy	*O. nivosa.*
„ like that of *O. nivosa* in shape, but far larger, proportionally much thinner, and of a more delicate texture	*O. truncatula.*
„ nearly cylindrical, with a rounded and produced base, thin, transparent, and polished	*O. clavula.*

Shell, nearly cylindrical, solid, opaque, glossy	*O. Lukisi.*
„ cylindro-conical, rather thin, semi-transparent, and of a dullish hue	*O. albella.*
„ conic oblong, inclining to oval, thin, transparent, and glossy	*O. rissoides.*
„ somewhat spindle-shaped in consequence of the elongation and angularity of the base, rather solid, nearly opaque, and moderately glossy	*O. pallida.*
„ oblong, conical, with a narrow and somewhat pointed base, solid, nearly opaque, of a polished lustre	*O. conoidea.*
„ forming a short cone, thin, transparent, and remarkably glossy	*O. umbilicaris.*
„ pyramidal, with a broad base, rather solid, but semi-transparent and lustrous	*O. acuta.*
„ forming an elongated cone, with rather a broader base, solid, opaque, glossy, and of a polished appearance	*O. conspicua.*
„ a rather long cone, with a broad base, solid, almost opaque, and glossy	*O. unidentata.*
„ forming a somewhat cylindrical cone, strong and solid, semi-transparent and glossy	*O. turrita.*
„ slender, with a narrow and attenuated base, thin, slightly channeled, and somewhat oblique	*O. insculpta.*
„ inclining to spindle-shaped, very thin, nearly transparent, and lustrous	*O. diaphana.*
„ shaped like a univalve *Limnæa* of the *stagnalis* type, extremely thin, transparent, and glossy	*O. obliqua.*
„ oval, resembling *Dolium perdix* in shape, rather thin, semi-transparent, and somewhat glossy	*O. dolioliformis.*
„ conic oblong, with a rather narrow base, thinnish, semi-transparent, and somewhat glossy	*O. decussata.*
„ cylindro-conical, solid, opaque, and not so glossy as most of its congeners	*O. clathrata.*
„ cylindrical and slender, rather thin, semi-transparent, and glossy	*O. indistincta.*
„ conic oblong, rather solid, semi-transparent, and glossy	*O. interstincta.*
„ conic oblong, inclining to oblong, with a wide base, which is somewhat angulated, rather solid, semi-transparent, and glossy	*O. spiralis.*
„ oblong, rather solid, semi-transparent, and glossy	*O. eximia.*
„ forming an elongated pyramid, rather solid, almost opaque, glossy	*O. fenestrata.*
„ pyramidal, solid, opaque, rather glossy	*O. excavata.*
„ forming a very elongated cone, moderately solid, opaque, rather glossy	*O. scalaris.*
„ forming an attenuated cone, moderately solid, opaque, and glossy	*O. rufa.*
„ forming a greatly elongated cone, rather solid, nearly opaque, and glossy	*O. lactea.*
„ shorter and more cylindrical than in *O. lactea*, being of nearly equal breadth throughout, instead of pyramidal, and becoming gradually broader towards the base; it is also more solid	*O. pusilla.*
„ forming a greatly elongated cone, with a comparatively broad base, rather solid, semi-transparent, and of a polished lustre	*O. Scillæ.*
„ forming an attenuated and somewhat cylindrical cone, rather thin, semi-transparent, and of a polished lustre	*O. acicula.*
„ needle-shaped, very thin, transparent, and lustrous	*O. nitidissima.*
„ oval or elongated	*Stilifer.*
„ globosely conical or oval, with an obliquely rounded base, thin, semi-transparent, and lustrous	*S. Turtoni.*
„ awl-shaped, polished, and lustrous	*Eulima.*
„ club-shaped, solid, opaque, and extremely glossy	*E. polita.*
„ smaller than in *E. polita*, having a narrower base, and is consequently more spindle-shaped; it is not quite so solid, and live specimens are semi-transparent	*E. intermedia.*
Shell, much smaller, slenderer, and thinner than in either of the foregoing species	*E. distorta.*
„ spike-shaped, slender, thin, transparent, glossy, and of a brilliant lustre	*E. stenostoma.*
„ awl-shaped, rather thin, semi-transparent, of a polished lustre	*E. subulata.*
„ a miniature resemblance of that of *E. subulata*, but proportionally more solid, and less slender	*E. bilineata.*
Spire, pointed, with an inflected and mostly a reversed apex	*Pyramidellidæ.*
„ elegantly tapering to a blunt point, which, when viewed sideways, appears button-shaped, and projects a little beyond the succeeding part of the spire; if viewed from above, it appears inflected; whorls, 9 or 10, moderately convex, and gradually increasing; the first whorl and half the next form the apex of the spire; suture deep, rather oblique	*Aclis unica.*
„ tapering to apparently a fine point; whorls, 8 or 9, convex in the middle, but compressed or sloping on the upper part of each towards the suture, they enlarge rather suddenly; suture deep, and rather oblique	*A. ascaris.*
„ conformable to the family type; suture more deeply excavated than in *A. ascaris*, and the whorls 12 in number	*A. supranitida.*
„ tapering to a blunt point, which is unmistakably introverted; whorls 10, rather convex in the middle, with a slope above and below; suture deep, and nearly straight	*A. Walleri.*
„ gradually tapering to a blunt and nearly globular point, which is decidedly introverted, but not sinistral; whorls 6 to 7, convex; suture deep, rather oblique	*A. Gulsonæ.*
„ having the first or top whorls sinistral, and turned backwards	*Odostomia.*
„ gradually tapering to a blunt, nearly globular, and inverted point; whorls 4 or 5, convex; the last is proportionally broader than the next, and exceeds in length the rest of the spire when the shell is placed with its mouth uppermost; suture deep, scarcely oblique	*O. minima.*
„ tapering to an abrupt rounded and inverted point, the apex being sunk or involved in the extremity of the spire; whorls 4 to 5, somewhat compressed; the last exceeds all the rest in length and bulk; suture rather deep, distinctly marked by the uppermost spiral ridge	*O. nivosa.*
„ turreted in aspect, owing to the deep channeling of the suture; whorls 6 or 7, flatter than in *O. nivosa*	*O. truncatula.*
„ turreted, and apparently truncated at the point, which is rounded and inverted; whorls 4 to 5, rather convex, although compressed and gradually enlarging; the last two are almost equal in breadth, and the body whorl somewhat exceeds in length the rest of the spire; suture nearly straight, slightly channeled above; it is defined on the inner side by a narrow rim, arising from the double layer of shell in that part, the upper edge of the lower whorl being soldered on the periphery of the preceding whorl	*O. clavula.*
„ abruptly terminating; whorls 5 to 6; convex, compact, gradually enlarging; the penultimate one projects a little, and is nearly as broad as the last, which	

occupies about three-fifths of the shell; suture rather deep . . . . . *O. Lukisi.*

Spire, tapering to a blunt point; the apex shows distinctly the reversed and inverted embryonic nucleus; whorls 5 to 6, rounded, but somewhat compressed, gradually enlarging; the last occupies about three-fifths of the shell; suture shallow, but incised; below it each whorl appears encircled by a narrow band, as in *O. rissoides*. . . . *O. albella.*

„ turreted, and tapering to a blunt point; the nucleus is concealed; whorls 5, rapidly enlarging; the last occupies two-thirds of the shell; suture rather deep; in living or fresh specimens the dark spiral band noticed in other species is observable below the suture on the top of each whorl . . . *O. rissoides.*

„ finely and regularly tapering to a blunt point; nucleus concealed; whorls six or seven, rather compressed, rapidly enlarging; the last occupies nearly two-thirds of the shell; suture more or less oblique, not deep, but distinct; the marginal band is observable in young specimens only . . . . . . *O. pallida.*

„ tapering to an abrupt extremity, nucleus concealed and twisted inwards; whorls eight, nearly flat, and gradually enlarging; the last constitutes about one-half of the shell; suture narrow and slightly channeled; it slopes downwards from the peripheral keel on each of the upper whorls. . . . . *O. conoidea.*

„ short, ending in a rather blunt and rounded point, owing to the inversion of the apex; whorls 5 or 6, convex very compact, gradually enlarging; the last occupies three-fifths of the shell; suture deep, imparting a slightly turreted appearance to the whorls; owing to the transparency of the shell, the periphery of each of the upper whorls appears like a narrow band round the top of the succeeding whorl . . . . . *O. umbilicaris.*

„ gradually tapering; nucleus exposed and inverted on the back in nearly a horizontal position; whorls 6 (besides the embryonic ones rounded), although compressed, compact and gradually enlarging, the last occupies about one-half of the shell; suture very narrow and slightly excavated, sloping a little downwards in consequence of the peripheral keel . . . . *O. acuta.*

„ pyramidally tapering; nucleus exposed and lying in nearly a horizontal position across the apex; whorls 8 (besides 2, which are embryonic and reversed), flattened; the last occupies about one-half of the shell; suture narrow, but excavated, sloping downwards in consequence of the peripheral keel . . *O conspicua.*

„ shortish; nucleus exposed, diverted, in some specimens backwards, and in others forwards; whorls 6, besides those of the embryonic nucleus; they gradually enlarge and are nearly flat; the last equal in length to the rest of the spire; suture narrow, but distinct, defined above by the peripheral keels from which it slopes downwards . . *O. unidentata.*

„ rather long, turreted and abruptly terminating; nucleus exposed, usually twisted forwards; whorls 5 to 6 (besides those composing the nucleus), convex and gradually enlarging; the last forms one-half of the spire, and scarcely exceeds the next in breadth; suture narrow, but well defined . . . . *O. turrita.*

Spire, long and finely tapering to a blunt point, nucleus exposed, and pointed in different directions; whorls 5 or 6 (exclusive of the nucleus) rounded, but much compressed, and gradually enlarging; the last occupies rather more than one-half of the shell if viewed with the mouth downwards; suture slight, somewhat more oblique than in the last species . . . . *O. plicata.*

„ long, somewhat turreted, and having a truncated apex; nucleus obliquely declining and concealed; whorls 6, convex, although more or less compressed; each has a narrow and thick rim immediately below the suture; the rate of their enlargement is rather quick, the last occupying about one-half of the shell; suture narrow, slightly channeled, and somewhat oblique . . *O. insculpta.*

„ rather long, abruptly truncated, nucleus obliquely declining and concealed, raised in front and twisted backwards; whorls 4, convex and rapidly enlarging; the last occupies two-thirds of the shell; the upper part of each is encircled by a thickened rim; suture narrow, but well defined, and oblique . . . *O. diaphana.*

„ long and tapering, somewhat turreted, nucleus partly exposed, and prominent, twisted upwards in front and sloping towards the back; whorls 5 (including the uppermost, from which the nucleus springs), tumid, and very rapidly enlarging; the last constitutes more than two-thirds of the shell; suture deep and oblique . . . . . *O. obliqua.*

„ remarkably short; nucleus twisted horizontally in different directions; whorls 3 only (besides those of the nucleus or apex); they are ventricose, but compressed towards the suture and front edge, and suddenly enlarge; the last occupies nearly the whole of the shell when viewed with the mouth upwards, and at least two-thirds when viewed in an opposite position; suture channeled, rather oblique . . . . . *O. dolioliform*

„ produced, slightly turreted, nucleus raised in front on one side and twisted inwards; whorls 4 (besides those forming the nucleus) convex, and rather quickly enlarging; the last occupies nearly three-fifths of the shell; suture deep and channeled, somewhat oblique . . . *O. decussata.*

„ elongated and tapering to an abruptly pointed extremity; nucleus raised on one side and twisted inwards; whorls 6 or 7, evenly convex; the last occupies more than two-fifths of the shell; suture rather wide and deep, somewhat oblique . . . . *O. clathrata.*

„ considerably elongated and gradually tapering to an abruptly truncated extremity; nucleus twisted inwards; whorls 7 or 8, convex, depressed below the suture and also on the upper part of the spire; they shelve abruptly downwards towards the suture on the lower side; the last occupies about two-fifths of the shell; suture narrow and deep, nearly straight on the upper part of the spire, becoming somewhat oblique on the lower part . . . . . *O. indistinct*

„ more or less elongated and tapering to a blunt extremity; nucleus smooth, higher on one side and twisted inwards; whorls 5 or 6, compressed rather than convex, shelving abruptly towards the suture, each having a thickened rim round the top; the last occupies more than one-half of the shell; suture narrow, but deeply excavated, scarcely oblique . . . . *O. interstincta.*

Spire, pyramidal and ending in a blunt point; nucleus obliquely twisted inwards; whorls 5 or 6, convex but flattened, rapidly enlarging, and abruptly shelving towards the suture; the last occupies about three-fifths of the shell; suture narrow and deeply excavated, nearly straight . . . . . *O. spiralis.*

„ tapering to a rounded point, nucleus globular and twisted inwards in various directions; whorls 4 or 5, very convex and almost tumid, gradually enlarging; the last occupies more than half the shell; suture very deep and nearly straight . . . . *O. eximia.*

„ remarkably turreted, in consequence of each whorl being broader at the base than the upper part of the succeeding whorl, and appearing to overlap the suture in an imbricating manner; nucleus somewhat excentric and prominent, abruptly twisted inwards; whorls 8 or 9, compressed or shelving upwards towards the suture, and moderately on the lower part; the last occupies about one-third of the shell; suture deep and slightly oblique . . . . . *O. fenestrata.*

„ tapering to a bluntly rounded point; nucleus somewhat excentric, and twisted inwards; whorls 6, turreted, flattened (except for the angularity caused by the excavated sculpture), and gradually enlarging; the last occupies rather more than half the shell; suture broad and remarkably deep, slightly oblique . *O. excavata.*

„ tapering somewhat abruptly to a rounded point, which forms the nucleus or crown; this is remarkably prominent, and although twisted inwards, it exposes nearly the whole of the reversed portion of the spire; whorls 8 (exclusive of the nucleus), turreted, convex, but compressed, and gradually enlarging; the last occupies about two-fifths of the shell; suture deep, slightly oblique . . . . *O. scalaris.*

„ greatly elongated, tapering to a rounded point which forms the nucleus; this is remarkably prominent, and exposes the reversed and compact spire of the embryo, which bends downwards to the first regular whorl in various directions; whorls 10 to 13 (exclusive of the nucleus), convex, although more or less compressed, and gradually enlarging; the last occupies from a third to a fourth of the shell; suture narrow and deep, slightly oblique . . . *O. rufa.*

„ tapering to a rounded point; embryonic nucleus as in the last species; whorls 12 (exclusive of the nucleus), moderately convex, and gradually enlarging, the last occupies from a fourth to a third of the shell; suture narrow and deep, slightly oblique . . . . *O. lactea.*

„ has a quasi-truncated appearance owing to the rapidly increasing size of the whorls, which are more rounded and compact than those of *O. lactea*, and 12 in number (excluding the nucleus) . *O. pusilla.*

„ tapering to a rounded point, nucleus exposed, twisted horizontally across the top of the first regular whorl, and resembling a young *Spirialis retroversus;* whorls 11 or 12 (exclusive of the nucleus), gradually enlarging, flattened (especially on the upper part), more or less angulated on the lower part and at the base of the shell, which is remarkably depressed, and contracted inwards; the last whorl occupies about one-third of the shell; suture very narrow, slightly excavated, and nearly straight; it appears, like many of its congeners, edged by a darkish band on the upper part of each whorl, owing to the periphery of the preceding whorl being visible through the partial transparency of the shell . . . . . . *O. Scillæ.*

Spire, gradually tapering to a blunt point; nucleus like that of the last species; whorls 8 to 9 (besides the nucleus), regularly increasing in size; they are usually flattened, but never angulated; the last occupies from nearly half to a third of the shell; suture very narrow, slightly excavated, somewhat oblique, and margined in the manner described in other species . . . . . *O. acicula.*

„ gracefully tapering to a blunt point, nucleus entirely exposed, and twisted obliquely upwards in various directions, resembling a miniature *Spirialis;* whorls 7 (besides the nucleus), very convex, and gradually enlarging; the last occupies rather more than one-third of the shell; suture wide and deep, decidedly oblique, and microscopically notched across . . . . *O. nitidissima.*

„ compact, with a stiliform and excentric apex . . . . *Stilifer.*

„ divided into two parts, the first formed part, or nucleus, consisting of a minute and very short cylinder, which is erect, although twisted slantingly in different directions; the other part or main body of the species short and abruptly separated from the nucleus; whorls 3 or 4 (besides 2 or 3, which compose the stiliform apex), very tumid, and rapidly enlarging; the last is enormous in proportion to the others; suture rather slight but distinct . . . . *S. Turtoni.*

„ finely tapering to a regular point, with an extremely slight suture or line of separation between the whorls . . *Eulima.*

„ long, somewhat cylindrical, and sharp-pointed, the upper part is occasionally curved; whorls 15 to 18, nearly flat, compact, and gradually enlarging, except the last, which occupies about one-third of the spire; the first semi-globular, and it appears to be diverted, and to have a bright spot or nucleus in the centre; suture slightly oblique, defined more by the darker colour of the line where one whorl envelopes the periphery of the next above it than by any groove . . . . *E. polita.*

„ proportionally shorter, and never twisted; whorls 15 to 16, more compact, and less flattened than in the other species; suture marked by a broad clear band . *E. intermedia.*

„ narrow, more or less curved so as to give the shell a distorted appearance; whorls 10 to 15, flattened; suture marked by fine line . . . . *E. distorta.*

„ elongated, ending abruptly in a blunt and semi-globular point; whorls 9, drawn out and gently swelling; the last occupies nearly one-half of the spire; suture oblique, defined by a rather broad hem or border of flake white, which is encircled underneath by a clear and narrow line; this hem or border arises from a thickening of the shelly material to form the suture or commissure . . . . . . *E. stenostoma.*

„ tapering to a fine point; whorls 12 to 13, rounded but compressed, the last occupying about three-sevenths of the spire; suture oblique, defined by a narrow dark line . . . . *E. subulata.*

Mouth, oval, somewhat angulated, but not channeled below; outer lip thin . . . *Pyramidellidæ.*

„ slightly expanded, and having a more or less complete peristome; pillar never furnished with any fold or tooth . *Aclis.*

„ exactly oval, effuse below; outer lip slightly flexuous, incurved above; inner lip thin, adhering to the pillar, connected with the upper lip at the outer corner; there is no umbilicus, but the base is narrowly depressed behind the pillar . *A. unica.*

„ exactly oval, effuse below; outer lip slightly flexuous, incurved above, more or less thickened near the edges, so as occasionally to form a varix in an earlier stage of growth; inner lip somewhat thickened and adhering to the pillar, reflected near the base; it is imperfectly connected with the outer lip at the upper corner; behind it is a small and narrow umbilical chink . *A. ascaris.*

„ more round than oval . . . . *A. supranitida.*

„ roundish oval, considerably dilated at the base; outer lip flexuous, prominent, and somewhat expanding; inner lip nearly straight and reflected at the base, apparently wanting on the upper part of the pillar; therefore separate from the outer lip; umbilicus small but distinct. . . . . . . *A Walleri.*

„ roundish oval, having the outer base somewhat truncated and deeply sinuated or almost notched; outer lip remarkably flexuous, prominent, and expanding; inner or pillar-lip short, nearly straight, and slightly reflected near the base, not united with the outer lip; behind it is a slight depression and narrow chink, but no umbilicus . . *A. Gulsonæ.*

„ expanding at the base; inner lip very rarely united with the outer lip; pillar usually straight and furnished in the middle with a single tooth or plait . *Odostomia.*

„ exactly oval, slightly expanded, but entire at the base; it occupies nearly one-third of the shell; outer lip somewhat flexuous, but neither prominent nor expanded; inner lip thin, adhering to the upper slope of the base, and slightly reflected below; it is united with the outer lip so as to form a continuous but indistinct peristome; umbilicus small and narrow; tooth or fold slight and seldom visible . . . *O. minima.*

„ oval, much narrower above than below, where it is expanded; it is scarcely equal in length to one-fourth of the spire; outer lip flexuous, inflected, and contracted at the upper part; inner lip not very thin, adhering to the pillar, slightly reflected over the base, and occasionally united with the outer lip; umbilicus none, but a narrow chink may be observed in aged specimens; tooth small, usually concealed behind the pillar . . . . *O. nivosa.*

„ longer in proportion to the breadth than in *O. nivosa;* outer lip emarginate or notched near its junction with the body whorl; the tooth is plait-like or twisted *O. truncatula.*

„ oval, expanded below; it occupies about one-third of the shell; outer lip rounded but not prominent, contracted and somewhat sharply reflected above, just below the periphery; inner lip not perceptible on the upper slope of the base, slightly reflected, and but little curved below; umbilicus very small and narrow but distinct; tooth or fold inconspicuous or scarcely discernible . . *O. clavula.*

Mouth, oval, contracted above, and expanded below, somewhat exceeding in length one-third of the spire; throat quite smooth; outer lip incurved on the periphery; inner lip thickened and spread on the pillar, joining the outer lip at the upper corner of the mouth, and slightly reflected on the lower side; umbilicus small but distinct; tooth small, prominent, and placed opposite the umbilicus . . . . . *O. Lukisi.*

„ oval, contracted on the outer side, slightly expanded and obtusely angulated at the base; it usually equals in length one-third of the spire; outer lip slightly curved; inner lip not much spread on the pillar, nor united above with the upper lip; thickened and slightly reflected on the lower side; umbilicus none, although there is sometimes a narrow chink behind the inner lip; tooth, small, retired, and nearly hidden within the pillar . . *O. albella.*

„ regularly oval, not much expanded, nor at all angulated below; it usually equals in length two-fifths (sometimes nearly one-half) of the spire; outer lip curved, and rather prominent; inner lip very slight on the upper part, forming a mere film on the pillar, thickened, and somewhat reflected on the lower part; umbilicus usually none, although in specimens which have a short spire there is a more or less developed chink or indentation; tooth small, and partly concealed . . . . *O. rissoides.*

„ more oblong than oval, contracted above, considerably expanded and angulated below; its length is about three-sevenths of the whole spire; outer lip gently curved, not very prominent; inner lip very slight on the upper part, forming a mere film on the pillar, thickened, and decidedly reflected on the lower part, where it is nearly straight; umbilicus none; the chink, when it exists, is extremely narrow or small; tooth strong, partly concealed; it is (as usual) placed on the pillar in the middle of the inner lip, just where the reflection of the latter commences . *O. pallida.*

„ oval, contracted above, somewhat expanded, but scarcely angular below; its length is about one-third of the whole spire; outer lip gently curved, inflected just below the periphery; inside deeply grooved in the direction of the spire, like the barrel of a rifle; the grooves are 8 or 9 in number, and terminate in small denticles or notches within the mouth; they are often visible outside; inner lip adhering to the pillar above the tooth, and joining the outer lip at its upper angle, reflected and curved below the tooth; umbilicus small, but deep, partly covered by the reflexion of the inner lip; tooth strong, prominent and conspicuous, placed just behind the umbilicus; it winds round the pillar from one end of the spire to the other, like the worm of a corkscrew . . . . *O. conoidea.*

„ oval, expanding below; it sometimes exceeds in length one-third of the spire; outer lip slightly reflected, not much spread over the pillar, nor extending to the upper part of the upper lip; it is more or less angulated below;

umbilicus very distinct, although small; tooth small, prominent, and placed opposite the umbilicus . . . . *O. umbilicaris.*

Mouth roundish oval, contracted above, and somewhat expanded, but scarcely angular below; its length is less than a third of the whole spire; outer lip gently curved, inflected just below the periphery; inner lip adhering to the pillar above the tooth, and joining the outer lip at its upper angle, slightly reflected, and more or less curved below the tooth; umbilicus, developed, and conspicuous, although small; its entrance is through a channel behind the lower part of the inner lip; tooth strong and prominent, placed just behind the umbilical opening; in construction and extent it resembles that of the last species . . . . *O. acuta.*

„ rhomboidal, contracted above, considerably expanded and angulated below; its length somewhat exceeds a third of the whole spire; outer lip obtuse, angled in the middle, and incurved just below the periphery; the inside, or throat, is finely but obscurely grooved in the direction of the spire; inner lip slight on the upper part, where it adheres to the pillar and joins the outer lip, reflected and nearly straight on the lower part, the angle at the base being very remarkable; umbilicus extremely small, and almost covered by the lower part of the inner lip; tooth strong, prominent, and conspicuous; it forms a sharp fold or ridge, which winds along the pillar throughout the spire . . . . *O. conspicua.*

„ squarish, expanded, and forming nearly a right angle at the inner base; its length is about a third of the whole spire; outer lip nearly semi-circular, incurved (but not much) just below the periphery; inner lip extremely thin on the upper part, where it adheres to the pillar, but does not join the outer lip, reflected, and nearly straight on the lower part, the angle at the base being well marked; umbilicus none, although there is sometimes a small chink; tooth large, strong, prominent, and conspicuous, placed as in several of the species last described; it is continued throughout the spire . *O. unidentata.*

„ squarish, not much expanded or angulated at the inner base; it is proportionally small, and its length is scarcely a third of the whole spire; outer lip projecting but little beyond the periphery, below which it is considerably incurved towards the pillar, thus contracting the mouth; inner lip thin, and adhering to the pillar on the upper part, without joining the upper lip, thickened, reflected, and gently curved on the lower part, the basal angle being usually slight; umbilicus none; tooth small, not prominent, nor very conspicuous . . . . *O. turrita.*

„ oval, inclining to oblong, narrow, and acute-angled above, rounded, and scarcely expanded below; its length equals a third of the whole spire; outer lip rather flexuous, not projecting beyond the periphery; inner lip thin, adhering to the pillar on the upper part, and united with the outer lip; the lower portion is thickened, reflected and curved; umbilicus none, although full-grown specimens have a narrow chink; tooth small, more prominent and conspicuous than in the last species . . . . . . *O. plicata.*

Mouth irregularly oblong, owing to the inflexion and curvature of the outer lip; it is acute-angled above (but not so sharply as in *O. plicata*), and decidedly expanded below; its length equals a third of the whole spire; outer lip remarkably flexuous, retreating at the upper corner of the mouth, where it forms a deep sinus, and inflected in the middle, so as to contract the mouth on that side; inner lip as in the last species; the lower part, however, is more reflected and straight in the present species; umbilicus small and narrow; tooth, or rather an oblique fold, retired, and inconspicuous, although always present . . . *O. insculpta.*

„ rather oblong than oval, narrow, and acute-angled above, expanded below; its length exceeds two-fifths of the whole spire; outer lip flexuous, retreating at the upper corner of the mouth, where it forms a rather deep sinus, and projecting in the middle; inner lip extremely slight on the upper part, thickened, and gently curved, but very little reflected on the lower part; umbilicus developed in the adult only, when it is small and inconspicuous, being approached by a narrow canal or groove from the base; tooth consisting of an insignificant and retired fold . . . . . *O. diaphana.*

„ oblong, or pear-shaped, narrow, and contracted above, considerably expanded or effuse below; it exceeds in length two-fifths of the spire; outer lip flexuous, retreating, and situated at the upper corner of the mouth, where it is incurved on the periphery; inner lip receding (almost concealed from view), and remarkably thin on the upper part, thickened, and reflected, but not much curved on the lower part; it forms an obtuse angle or point at the base; umbilicus none, or consisting of an oblique depression, which sometimes ends in a small chink; tooth, only a slight and obscure fold . . *O. obliqua.*

„ roundish oval, not contracted above, slightly expanded below; it considerably exceeds in length one-half of the whole spire; outer lip abruptly incurved on the periphery; inner lip thin on the upper part (where it is united with the outer lip), broad, thickened, a little reflected, almost straight, and shelving outwards on the lower part, which is more than thrice as long as the other; umbilicus consisting of a narrow, although distinct, depression, which terminates in a small chink; tooth strong, conspicuous, like a short thorn, projecting from the middle of the inner or pillar lip . . *O. dolioliformis.*

„ oval, scarcely contracted above or expanded below; its length is about two-fifths of the whole spire; outer lip not much curved, abruptly inflected on the periphery; inner lip thin on the upper part, continuous with the lip in adult specimens, thickened, reflected, and inclining to straight on the lower part, which is twice as long as the other; umbilicus slight, forming a narrow chink behind the inner or pillar lip; tooth very retired and inconspicuous, consisting of a narrow, oblique fold, which, on breaking the shell, may be seen winding round the pillar . *O. decussata.*

Mouth roundish oval or regularly oval, very little contracted above or expanded below; length about one-fourth of the whole spire; outer lip rounded, sharply inflected below the periphery; inner lip retreating obliquely (but not very thin) on the upper part, where it is united with the outer lip, so as to form nearly a complete peristome, scarcely reflected and gently curved on the lower part; umbilicus developed more than in the allied species, and consisting of a narrow depression and chink behind the pillar lip; tooth or fold none *O. clathrata.*

„ oval, contracted above, and considerably expanded below; length not one-fourth of the whole spire; outer lip flexuous, retreating, and forming a sinus above, incurved below the periphery: inner lip extremely thin on the upper part, reflected, and nearly straight below; umbilicus consisting of a slight depression which ends in a small narrow chink; tooth or fold none . . . *O. indistincta.*

„ oval, somewhat contracted above, and much expanded below; its length equals, and in some cases exceeds, one-third of the whole spire; outer lip flexuous, slightly sinuated above, where it is gently incurved on the periphery; inner lip undistinguishable, and apparently wanting on the upper part, not much reflected (although sloping inwards) and nearly straight below, terminating in a rectangular base, like *O. unidentata;* umbilicus none, or consisting at the most of an indistinct and narrow chink, which, however, becomes considerably developed in aged specimens; tooth short and retired, but strong . . . . *O. interstincta.*

„ irregularly rhomboidal, forming an acute angle above, and considerably expanded below; its length equals two-fifths of the whole spire; outer lip sinuous, contracted in the upper part, sloping upward to the under side of the periphery; inner lip more or less distinct on the upper part of the pillar, according to the degree of maturity of the specimen, in other respects like *O. interstincta,* but not so straight on the lower part as in that shell, and terminating in an obtuse angle; umbilicus consisting of a more conspicuous chink than in the last-named species; tooth very short, blunt, and obscure, being seated far within the pillar . . . . . *O. spiralis.*

„ proportionally small, oval, expanded below; its length scarcely equals one-third of the whole spire; outer lip rounded, recurved on the lowermost spiral stria; inner lip nearly indistinct on the upper part, gently curved and slightly reflected below, and terminating at the base in an obtuse angled point; umbilicus extremely small and narrow, but distinct; tooth minute, somewhat retired and obscure . . *O. eximia.*

„ proportionally small, rhomboid, oval, contracted above, wide, slightly expanded, and decidedly angulated below; length scarcely exceeding one-sixth of the spire; outer lip gently rounded, recurved on the lowermost of the three main spiral ridges, by all of which it is notched or indented at the edge; inner lip forming on the upper part of the pillar a thin film which is united with the outer lip, on the lower part nearly straight and not much reflected, terminating in a rectangular point; umbilicus wanting, or now and then represented by a minute and narrow chink; tooth or fold none . . . . *O. fenestrata.*

Mouth squarish oval, not contracted above, expanded and angulated below; length about one-third of the spire; outer lip projecting, marked by four angular points, being the termination of the spiral ridges; it is abruptly recurved on the peripheral ridge; inner lip slight on the upper part, but united with the outer lip, reflected and almost straight below, where it also joins the outer lip at a right angle; umbilicus narrow and contracted, but distinct; tooth small and retired, although visible in every specimen, and winding round the pillar . . . . . . *O. excavata.*

„ irregularly rhomboidal, owing to the angular shape of the pillar side; it is somewhat contracted above and expanded below; length about a fourth of the spire; outer lip rounded, not much projecting, incurved a little below the periphery; inner lip adhering to the upper slope of the pillar (although scarcely perceptible), straight below and slightly reflected towards the base, where it shelves inwards; umbilicus or tooth none . . . *O. scalaris.*

„ irregularly rhomboidal, acute-angled above, and expanded below; length from a fifth to a sixth of the spire; outer lip somewhat contracted, very little incurved below the periphery; inner lip forming a thin film on the upper slope of the pillar, slightly reflected and nearly straight below; umbilicus none, except a slight depression of the base in adult specimens; tooth very retired, slight and indistinct, formed on the pillar near its junction with the upper slope of the base . . . . *O. rufa.*

„ irregularly rhomboidal, longer and more expanded at the base than in *O. rufa,* but similar in all other respects; outer lip gently rounded, except under the periphery, where it is very slightly incurved and shelves outwards; inner lip forming a thin glazing or layer on the upper slope of the pillar, very little reflected and nearly straight below, where it is more extended than in the last species; umbilicus none; tooth usually wanting, but in some specimens an obscure tubercle may be detected on the upper part of the pillar, far within the mouth . . . . *O. lactea.*

„ irregularly rhomboidal, contracted above, and expanded below; length between a fourth and a fifth of the spire; outer lip curved, except the upper side, which shelves gently outwards a little below the periphery; inner lip a mere film on the slope of the base, somewhat reflected and straight below; umbilicus usually none, although the above-mentioned depression of the base sometimes produces a small central cavity; tooth obscure, in one specimen like that of *O. pusilla* . . . . *O. Scillæ.*

„ irregularly and obliquely rhomboidal, contracted or narrow above, and expanded below; length about one-fourth of the spire; outer lip gently curved on the lower part, shelving or sloping downwards from a little below the periphery; inner lip imperceptible above

	the pillar, slightly reflected and straight (but now and then reversed or twisted) below; umbilicus none; tooth or fold rarely developed	*O. acicula.*
Mouth	regularly oval, not much expanded below; length about one-sixth of the spire; outer lip rounded, inflected just below the periphery; inner lip not so much curved, adhering to the upper slope of the base, where it is united to the outer lip, not reflected below; umbilicus and tooth none	*O. nitidissima.*
„	rounded or oval; lips disconnected	*Stilifer.*
„	more round than oval, not much expanded at the base; outer lip thin, inflected just below the periphery, whence it slopes obliquely downwards; inner lip consisting of an almost invisible film on the pillar, thicker below, and folded back over the pillar, which is deeply curved and flexuous	*S. Turtoni.*
„	pear-shaped; lips discontinuous	*Eulimidæ.*
„	acute-angled above, widening and expanded below; its length equals about one-fourth of the shell; outer lip flexuous, with a rather thick edge, not inflected on the periphery, but sloping from it downwards; inner lip consisting of a broadish porcellanous deposit, which is considerably thickened behind the pillar; the last is flexuous	*E. polita.*
„	narrower than in last species; outer lip rather more deeply sinuated above; inner lip slighter and thinner	*E. intermedia.*
„	as in *E. intermedia*	*E. distorta.*
„	narrow, extending from a sharp angle above to an expanded and rounded base; the inner or columellar side represents a very obtuse angle; outer lip flexuous, with a rather thin edge, receding at the top, and advancing outwards towards the base; inner lip reflected and twisted over the lower part of the pillar	*E. stenostoma.*
„	contracted, acute-angled above, and rounded, but not much expanding below; edges thickened; outer lip folded outwards at the upper part, and slightly flexuous; inner lip reflected over the whole pillar, which is decidedly flexuous	*E. subulata.*
„	not so narrow, and the outer lip more flexuous than in last species	*E. bilineata.*
Operculum	ear-shaped, with a short, imperfect spire of very few whorls; nucleus excentric on the inner side near the base	*Pyramidellidæ.*
„	light yellow and sub-oval, with distinct grossly spiral turns	*Aclis unica.*
„	filmy, wrinkled in the line of growth, composed of three turns, the last and outermost of which is disproportionately large; the line of division between these whorls is raised or ledge-like	*A. Walleri.*
„	an almost invisible film, pear-shaped or sub-oval, with a narrow border of pale bistre with a pinkish hue; the striæ of increment radiate as in most of the other *Chemnitziæ*	*A. Gulsonæ.*
„	semi-testaceous, having a thin flap on the outer side and a short apophysis or process underneath the nucleus of the spire	*Odostomia.*
„	pale yellow, delicately striated in the line of growth; spire consisting of two to three whorls	*O. minima.*
„	yellowish, strongly striated or furrowed in the line of growth, the striæ being more close-set and flexuous towards the outer side; spire very short and nearly terminal	*O. nivosa.*
Operculum	conspicuously striated	*O. truncatula.*
„	thin, finely striated	*O. clavula.*
„	yellowish, with a white streak in the line of the spire, very slightly striated across; flap broad; there is the same groove and corresponding ridge as in *O. conoidea*	*O. Lukisi.*
„	yellowish, marked with white down the spire, finely and deeply striated in the line of growth; flap not striated; groove and ridge as in *O. conoidea;* spire very short, indistinct, and nearly terminal	*O. albella.*
„	like that of *O. albella*	*O. rissoides.*
„	as in the last two species; the ridge well marked, and the striation very distinct	*O. pallida.*
„	yellowish brown, of equal proportionate solidity with that of *Cyclostoma elegans*, and exquisitely sculptured by close-set flexuous striæ in the line of growth; it has a curved groove down the middle, which ends in the spire of the operculum, and gives to the portion thus separated in front a cornucopia shape; this groove is deep and very distinct; side flap rather broad, widening with the growth of the operculum, and divided from the spiral part by a narrow line	*O. conoidea.*
„	yellowish and rather solid, closely and finely striated across; it is divided lengthwise about one-third the distance from the pillar by a curved groove, which forms a ridge on the under side; inner side straight; flap narrow; spire consisting of two or three whorls	*O. umbilicaris.*
„	yellowish brown, finely and closely striated; the curved groove is unusually distinct	*O. acuta.*
„	as in *O. conoidea*	*O. unidentata.*
„	of a thinner texture and less strongly striated than that of *O. conoidea*	*O. turrita.*
„	thicker on the inner than the outer side of the mouth; coarsely striated, and sometimes having a white streak down the middle	*O. plicata.*
„	remarkably thin, light horn colour, narrow and obliquely striated	*O. insculpta.*
„	extremely thin, except on the inner side, light yellow, scored obliquely by fine and close-set flexuous lines, and having a distinct, but short and nearly terminal spire of two minute whorls: it resembles in shape *Cristellaria*	*O. diaphana.*
„	as in last species, but less strongly striated	*O. obliqua.*
„	cartilaginous and flexible, with the striæ of growth arranged in elliptical curves, as in *O. pallida*	*O. dolioliformis.*
„	rather thin and delicately striated	*O. decussata.*
„	with a thin flap, and delicately striated	*O. indistincta.*
„	flexible, with a very thin flap, closely and finely striated in the line of growth, and presenting the usual triangular ridge on the pillar side, and a minute almost terminal spire	*O. interstincta.*
„	as in *O. interstincta;* the inner side is slightly notched to receive the tooth	*O. spiralis.*

Operculum	thin, exquisitely and closely striated in the line of growth . . .	*O. fenestrata.*
„	thin and flexible, irregularly striated; spire extremely short, minute and terminal	*O. scalaris.*
„	as in the last species . . .	*O. rufa.*
„	as in the two last species; sometimes slightly notched on the inner side to accommodate the tooth when present	*O. lactea.*
„	thin, and most delicately striated, with a very short spire . .	*O. acicula.*
„	rather solid, delicately striated in the line of growth, and having a narrow flap	*O. nitidissima.*
„	horny, with a short and incomplete spire, having its nucleus on the columellar or inner side . .	*Eulima.*
„	thin, pale yellowish horn colour, marked with microscopical and numerous flexuous striæ in the line of growth	*E. polita.*
„	filmy, pale yellowish horn colour, marked with slight flexuous striæ in the line of growth . .	*E. stenostoma.*
„	very thin, pale drab, and rather coarsely striated	*E. subulata.*
Size of shell—	length, ·115 in.; width, ·02 in. .	*Aclis unica.*
„	length, ·1 ; width, ·025 . . .	*A. ascaris.*
„	length, ·25 ; width, ·1 . . .	*A. supranitida.*
„	length, ·135 ; width, ·05 . .	*A. Walleri.*
„	length, ·065 ; width, ·025 . .	*A. Gulsonæ.*
„	length, ·05 ; width, ·025 . .	*Odostomia minima.*
„	length, ·0625 ; width, ·0325 . .	*O. nivosa.*
„	length, ·175 ; width, ·065 . .	*O. truncatula.*
„	length, ·08 ; width, ·04 . . .	*O. clavula.*
„	length, ·1 ; width, ·045 . .	*O. Lukisi.*
„	length, ·115 ; width, ·05 . . .	*O. albella.*
„	length, ·125 ; width, ·0625 . .	*O. rissoides.*
„	length, ·2 ; width, ·1 . . .	*O. pallida.*
„	length, ·25 ; width, ·1 . . .	*O. conoidea.*
„	length, ·1 ; width, ·05 . . .	*O. umbilicaris.*
„	length, ·175 ; width, ·075 . .	*O. acuta.*
„	length, ·35 ; width, ·15 . . .	*O. conspicua.*
„	length, ·2 ; width, ·1 . . .	*O. unidentata.*
„	length, ·125 ; width, ·05 . . .	*O. turrita.*
„	length, ·1 ; width, ·05 . . .	*O. plicata.*
„	length, ·15 ; width, ·0625 . .	*O. insculpta.*
„	length, ·1 ; width, ·05 . . .	*O. diaphana.*
„	length, ·2 ; width, ·075 . . .	*O. obliqua.*
„	length, ·075 ; width, ·05 . .	*O. dolioliformis.*
„	length, ·125 ; width, ·05 . . .	*O. decussata.*
„	length, ·165 ; width, ·05 . . .	*O. clathrata.*
„	length, ·165 ; width, ·04 . . .	*O. indistincta.*
„	length, ·125 ; width, ·04 . .	*O. interstincta.*
„	length, ·125 ; width, ·05 . . .	*O. spiralis.*
„	length, ·06 ; width, ·03 . .	*O. eximia.*
„	length, ·15 ; width, ·05 . . .	*O. fenestrata.*
„	length, ·15 ; width, ·06 . .	*O. excavata.*
„	length, ·25 ; width, ·085 . . .	*O. scalaris.*
„	length, ·35 ; width, ·1 . . .	*O. rufa.*
„	length, ·35 ; width, ·1 . . .	*O. lactea.*
„	length, ·275 ; width, ·075 . .	*O. pusilla.*
„	length, ·35 ; width, ·1 . . .	*O. Scillæ.*
„	length, ·175 ; width, ·05 . .	*O. acicula.*
„	length, ·1 ; width, ·02 . . .	*O. nitidissima.*
„	length, ·15 ; width, ·1 . . .	*Stilifer Turtoni.*
„	length, ·75 ; width, ·2 . . .	*Eulima polita.*
„	length, ·45 ; width, ·125 . .	*E. intermedia.*
„	length, ·2 ; width, ·05 . . .	*E. distorta.*
„	length, ·35 ; width, ·085 . .	*E. stenostoma.*
„	length, ·5 ; width, ·1 . . .	*E. subulata.*
„	length, ·3 ; width, ·075 . .	*E. bilineata.*
Habitat and range—	local in littoral zone, from Haroldswick Bay in Unst to Devonshire and Guernsey; it is also found off Loire Inférieure and Spezzia. It is lively, and in confinement constantly creeps up the deepest aquaria . . .	*Aclis unica.*

Habitat and range—	from Bergen and East Shetlands in 82 fathoms water to Devonshire, and near Cherbourg and Loire Inférieure ; coralline crag, Sutton . . .	*A. ascaris.*
„	from Bohuslan (12 fms.), Hebrides, and Ireland to Vigo Bay (8 fms.), Gulf of Lyons, and Algeria ; coralline crag . . .	*A. supranitid*
„	from about 100 miles N.E. of Hamilton's Inlet, Labrador (1622 fms.), Molde in Norway, and off Whalsey Skerries (70 fms.); coralline crag, Sutton .	*A. Walleri.*
„	coralline zone from Shetland to Guernsey and Vigo Bay; coralline crag, Clacton	*A. Gulsonæ.*
„	lives on decayed fronds, and at the base of *Laminariæ* just beyond low-water mark ; North of Scotland, Falmouth, and Guernsey. Rare . .	*Odostomia m nima.*
„	lower part of littoral zone, and upper part of laminarian zone from North Scotland to the South of England	*O. nivosa.*
„	from Turbot bank (20 fms.), near Larne, co. Antrim, to Falmouth and Plymouth	*O. truncatula.*
„	from the coast of Sweden, in mud (30 fms.), among *Pernatulæ*, to Hebrides and south coast of England. Rare, and usually occurs in muddy sand between 6 and 50 fms .	*O. clavula.*
„	Skye, Shetlands, Oban, 20 to 25 fms.; among seaweeds at low-water mark on South Devon coast ; Guernsey, 18 to 20 fms. .	*O. Lukisi.*
„	underneath loose stones and in the laminarian zones on various parts of our coasts from Guernsey to Shetland. Northwardly it extends to Norway, Sweden, and Denmark ; while southwardly it is found as far as Sardinia. Found in the boulder clay of Caithness and at Uddevalla ; and in a post glacial shell bank at Kirkoën, Norway . . .	*O. albella.*
„	lower part of the littoral zone, and throughout the laminarian zone on all our coasts. It has also been found at Bohuslan (15 to 30 fms.) ; on the Danish coasts ; at Spezzia, and at Algiers . .	*O. rissoides.*
„	especially frequents the ears of *Pecten opercularis* and *P. maximus* in the coralline zones from the Shetlands to Devonshire. It is also living in the Norwegian and Danish seas, in Vigo Bay, at Spezzia,	

and off the coasts of Dalmatia. It occurs as a fossil in the newer pliocene deposit at Belfast, and in the Clyde beds . *O. pallida.*

abitat and range—coralline and deep-sea zones, in mud, (from 25 to 80 fms.) throughout Shetland and Scotland. Locally plentiful in the Clyde district and the Hebrides. A variety ranges to the south shores of England and Ireland. The typical forms occur as far north as Hammerfest (40 fms.) and Gottenburg (12 fms.), while the variety is distributed on the European coasts from Brittany to every part of the Mediterranean and the inland seas connected with it. It is doubtful if it is found in the Red Sea, as reputed by Philippi; in the Canaries it inhabits depths of from 12 to 60 fathoms. It has been found in the upper miocene beds of Antibes; the coralline crag; the Clyde beds; the basaltic tufa at Militello; and the sub-Apennine tertiaries . *O. conoidea.*

„ coralline zone; from Bohuslan (12 fms.), Eggers Bank, Norway (150 fms.), and Shetlands, to the south coasts of England. Rare . . . . . . *O. umbilicaris.*

„ coralline zone; from Norway and Shetlands to Loire Inférieure, north coast of Spain (30 fms.), Teneriffe, and Spezzia. Known also as a pliocene species. It is a lively, active, and bold animal . *O. acuta.*

„ coralline zone; from Bohuslan and Shetlands to Brittany, Spain, Spezzia (10 to 12 fms.), Sardinia, and the Adriatic. Rare. *O. conspicua.*

„ under stones at low-water mark of spring-tides, and on old oyster-shells and *Pecten maximus* in the laminarian and coralline zones. From Hammerfest on the north (10 to 50 fms.) to Loire Inférieure, and perhaps Algeria, on the south. Found everywhere on the British coasts. Post-pliocene, Norway and Scotland . . . . *O unidentata.*

„ under stones and in rock pools at low water, and among sea-weed in the laminarian zone. Ranges from the Cattegat, Ireland, and Cornwall, to Brittany, Teneriffe, and Spezzia. Not uncommon. It floats; and, when crawling, it withdraws its eyes, which are visible through the shell . . *O. turrita.*

„ under loose stones and among sea-weeds. Occurs on the south coasts of Ireland and England, and ranges southwards along the shores of France, Italy, Austria, and Algeria . . . . . *O. plicata.*

Habitat and range—coralline and deep-sea zone throughout the British seas (from 28 to 85 fms.); not common. In the north, it lives at Drobak Christianifiord (50 fms.); Loffoden Isles (50 to 100 fms.); and South Sweden; while to the south it is reported from Brittany. It is a pliocene species at Sutton, and a post-pliocene one at Drontheim *O. insculpta.*

„ coralline zone (12 to 50 fms.); from the Shetlands to Guernsey. Local and rare *O. diaphana.*

„ the type ranges from South Sweden (20 fms.), and Shetlands to Normandy; but as a variety it extends to Cannes and Spezzia . *O. obliqua.*

„ from the Hebrides and North Scotland to Brittany and Spezzia . . *O. dolioliformis.*

„ coralline zone; from Shetlands to North of France; not uncommon as a British species. Occurs in the pliocene at Sutton . . . . . *O. decussata.*

„ Galway (15 fms.), Malta, Spezzia, and Orotava. Very rare . . . . *O. clathrata.*

„ from 4 to 40 fms. on British shores; a variety inhabits a peculiar district of shelly mud between the laminarian and coralline zones in 10 fathoms water, off Teignmouth. Ranges from Christianifiord (10 to 50 fms.), Bohuslan (12 fms.) to Gibraltar, Mediterranean and Canary Islands (40 to 60 fms.). Pliocene at Sutton, and post-pliocene in Norway *O. indistincta.*

„ coralline and laminarian zones; nestles among stones and old shells, and occasionally at the base of sea-weeds in rock pools at spring-tides. Common. Generally distributed in the North Atlantic from Norway, Denmark, Loffoden Isles, to the south of France; it is also plentiful in the Mediterranean. Pliocene at Sutton; post-pliocene in Norway . . . . *O. interstincta.*

„ has nearly the same distribution and habitats as the last species . . *O. spiralis.*

„ from Bergen and Christianifiord to Shetlands and Ross-shire (60 fms.). None of the Scoth specimens have contained the animal, although the shells appeared to be recent. Post-pliocene in the Christiania district . . *O. eximia.*

Habitat and range—	muddy and sandy ground in shallow water, from south coasts of England to Vigo Bay, Spezzia, and Algiers	*O. fenestrata.*
”	coralline zone; from Ireland, Scotland, and south coasts of England to Cannes, Spezzia, the Adriatic, and Algiers. The British specimens are larger than those from the Mediterranean	*O. excavata.*
”	coralline zone; the type extends from Ireland and south coasts of England to Spain and the Mediterranean, living in depths varying from 8 to 35 fms. A variety has a more northern distribution, having been found off Norway, Massachusetts, New England, the Shetlands, and northern portions of Scotland and Ireland; it is also a British pliocene species	*O. scalaris.*
”	the type occurs in shallow water off the coasts of Wales and of south-west England, and is rare. Its southern limits range to the Canary Islands and Adriatic, in depths of from 8 to 30 fms. A variety frequents more northern areas, such as Sweden, Norway, Shetland isles, Scotland, and deeper waters (30 to 90 fms.); it is a post-pliocene shell at Skien in the Christiania district	*O. rufa.*
”	laminarian zone; from Ross-shire and Aberdeenshire to south coast of England. Out of Great Britain it is known from Finmark on the north to the Canary isles and the Mediterranean on the south. Probably a pliocene species in south of England	*O. lactea.*
”	is frequently associated with the last species; ranges from southern England to Algiers	*O. pusilla.*
”	muddy sand; from Finmark to the Canary isles; 12 to 200 fathoms. Found in Italy. When crawling the animal trails its long shell horizontally behind it	*O. Scillæ.*
”	coralline zone; muddy sand; from Norway to the Adriatic, at depths of from 10 to 41 fathoms. Post-pliocene in Caithness and at Palermo	*O. acicula.*

Habitat and range—	from Finmark to Gulf of Lyons and Spezzia, in depths of from 5 to 30 fathoms	*O. nitidissim*
”	on various species of *Echini*, from Norway to the Canary isles	*Stilifer T* *toni.*
”	muddy sand; from Finmark to the Ægean Sea, at depths varying from 2 to 145 fms. Miocene at Vienna; pliocene in England; and post-pliocene in Norway	*Eulima poli*
”	generally associated with the last species and having a similar range; it occurs in depths of from 15 to 73 fathoms; miocene in France; pliocene in England, and fossil in Italy. It floats; and in the floating position it remains suspended by means of a byssal thread, the operculum then closing the mouth of the shell	*E. intermedi*
”	widely diffused (though local), from low-water mark of the equinoctial tides in rock pools, among *Zostera*, and under stones, at Jersey, to a sandy bottom in the greatest depths of the North Sea. A variety inhabits deep water on the Scotch shores. It ranges from Finmark to the Canary isles and the Mediterranean, at depths of from 10 to 140 fathoms. Miocene in France; post-pliocene in Norway and Sicily	*E. distorta.*
”	fine sandy mud; 30 to 50 miles off the Whalsey Skerries (75 to 90 fms.); Norway. Rare. Very active, and will not stop in the water of an aquarium	*E. stenostom*
”	coralline zone; from the Shetlands to North Africa, at depths of from 2 to 140 fathoms	*E. subulata.*
”	locally but widely dispersed from low-water mark at Jersey under loose stones, to 82 fathoms off the east coast of Shetland in muddy sand. The foreign localities are included between Scandinavia and the Gulf of Lyons. It crawls at a tolerably fast pace, and gets out of the water whenever it is immersed.	*E. bilineata.*

(Jeffreys, *British Conchology*, vol. iv.)

Q

QUARTZ [E. C. vol. iv. col. 515]. Under SILICA, E. C. S., some general remarks are made on silica, and attention is drawn to its striking structural modifications. In this article we propose to treat not only of the native forms of dense silica, of which the majority of the substances called quartz is composed, but also of the minerals which consist mainly of the lighter silica, or *metasilica*, such as opal, hyalite, &c.; in short, we include all details which are intended to supplement the articles QUARTZ; AMETHYST, vol. i. col. 102; AGATE, vol. i. col. 89; AVANTURINE, vol. i. col. 350; BLOODSTONE, vol. i. col. 522; FLINT AND FLINTY SLATE, vol. ii. col. 834; and OPAL, vol. iv. col. 91.

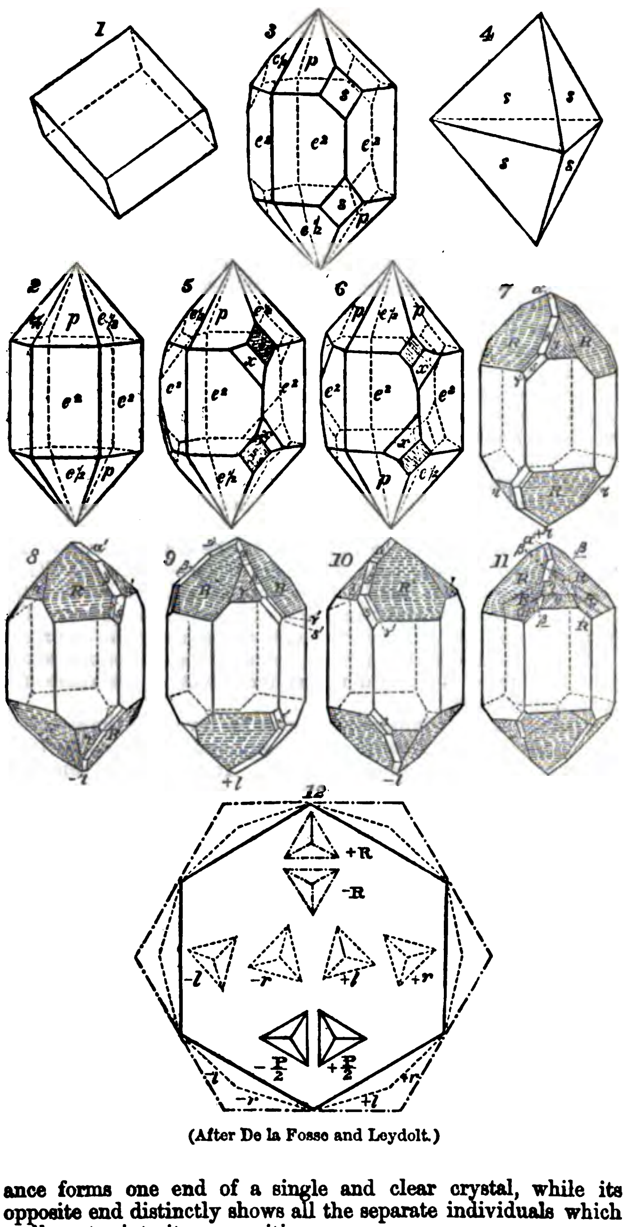
As has already been noticed under QUARTZ, E. C., quartz usually occurs in hexagonal prisms with pyramidal summits, the primary form being a rhombohedron, with an angle of 94° 15′ (*fig.* 1). Notwithstanding the geometrical symmetry, the perfect transparency, and the apparent homogeneity of ordinary rock crystal, the recent researches of crystallographers have shown that its structure is exceedingly complicated; that almost every specimen is composed of two or more crystals; and that the same specimen presents different properties in different parts, due to its heterogeneous physical nature, caused apparently by variations in the mode of arrangement of its particles.

The primitive rhombohedron (*fig.* 1) differs from that of the ordinary hexagonal system of crystallization in that the lateral contiguous edges are not physically alike. From this cause it frequently happens that crystals are formed which may be derived by modifying one-half the edges of the primitive rhombohedron to the exclusion of the other half. We cannot here give many details respecting these modifications; but the subject has been ably discussed by M. Descloizeaux in his memoir on the crystallization and structure of quartz, in which he describes upwards of 150 simple forms which are capable of separate existence, but which have as yet only been met with in quartz combined with and subordinate to the pyramidal prismatic form. Weiss also has written a lengthy paper on the crystallization of quartz, in which he pointed out the peculiarities which distinguish the crystalline system of quartz from that of the hexagonal system proper, and urged how significant some of the minor irregularly situated facets were in indicating the structure of the crystal.

The true primitive rhombohedron is of very rare occurrence, but it has been met with at a few localities in Brazil and Russia. The most common is that shown in *fig.* 2; but it is frequently combined with certain facets which appear to occupy abnormal positions. It is a combination of the primitive rhombohedron, *p*, with its inverse, $e\frac{1}{2}$, and with the hexagonal prism, e^2. The faces of the prism are always horizontally striated; the faces *p* and $e\frac{1}{2}$ differ in lustre, and frequently also in size, those marked *p* being generally the brightest and largest. They are not uncommonly spotted with slight depressions, having somewhat the form of small isosceles triangles. Another common form is the bipyramidal variety, in which the two summits of *fig.* 2, are placed base to base, the intervening faces, e^2, not being developed.

Amongst the forms with irregular faces may be mentioned that called the rhomb-bearing variety (*fig.* 3), which is the same as *fig.* 2 with the additional face, *s*. As will be noticed, the faces *s* are six in number, and are developed at the opposite ends of each alternate vertical edge. If they were developed to the exclusion of all the other faces, they would give rise to the form shown in *fig.* 4. Similar faces may occur on the other three alternate vertical edges, and if these were developed to their full extent they would give rise to a form like that of *fig.* 4, when seen in a glass. If all those faces were combined together, they would produce the double hexagonal pyramid or bipyramidal variety already alluded to. The two distinct sets of faces are called *right* and *left*, and may generally be recognised at a glance by noticing the direction in which their striations lie. Thus in the right faces the lines proceed from the right above to the left below, as shown in *fig.* 5, while in the left faces they proceed from the left above to the right below, as in *fig.* 6.

When a number of quartz crystals are grouped together, they are arranged according to some definite plan. When in simple juxtaposition they usually have their long axes parallel. This, perhaps, is the most common mode of occurrence. Frequently also two or more crystals are interblended together. In some cases they are so arranged that no difficulty is experienced in detecting the separate individuals; but in others, which are by no means rare, two individuals are completely interblended, and have their axes so perfectly parallel that the unaided eye is unable to distinguish them; and even when the axes are not parallel the compound nature of the group is not readily perceived. But no difficulty is experienced when recourse is had to polarized light or to the slow decomposing action of hydrofluoric acid. In some rare examples a number of similar crystals are blended together into a mass which to all appearance forms one end of a single and clear crystal, while its opposite end distinctly shows all the separate individuals which really enter into its composition.



(After De la Fosse and Leydolt.)

When a plate of quartz is examined by means of polarized light, it exhibits the phenomenon known as *circular polarization.* As it would take up more space than is consistent with the subject of this article to explain what is meant by circular polarization, we must content ourselves with saying that when a plate of quartz cut at right angles to the principal axis of the crystal exhibits it, the observer sees a number of concentric rings brilliantly coloured according to the thickness of the plate. In other uniaxial crystals the concentric rings are interrupted by a dark cross. In quartz this cross is faintly perceptible on the outermost rings, the centre showing no signs of it. If the plate of quartz is turned round without shifting its plane, no alteration in the colours will be perceived ; but if the analyser of the polarizing apparatus be turned, the colours will change, and the order of change will depend upon the structure of the plate, while the rapidity will depend upon its thickness. The order is always that which the colours have in the ordinary prismatic spectrum, and may be either towards the red or the violet end ; and the rate is measured by the number of degrees through which the analyser is turned or rotated to produce a given effect. For example, if when the two Nicol prisms are so arranged as to entirely exclude light, we place between them a red glass plate, nothing will be noticed ; but if in addition a plate of quartz, say 3·75 millimètres thick, be interposed, a red light is immediately perceived ; and in order to restore darkness the analyser will require to be rotated through an angle of 56¼°. If an orange-coloured glass had been used in place of the red one the amount of rotation required to exclude the orange light would have been greater, or 71¼° ; and in proportion as the colour used is situated nearer the violet end of the spectrum, so will the angle of rotation require to be increased, that for violet light being 165°. There is, however, a further peculiarity arising from the nature of the quartz, for while in some specimens darkness is produced when the direction of rotation is to the right, and the colours change to tints nearer to the violet end than themselves when the analyser is turned to the left ; so there are other specimens in which the darkness is restored by rotation to the left, the opposite direction causing the colours to change towards violet. The former belong to crystals having the form of *fig.* 5, and are hence called *dextrogyral* or *dextrorotatory*, and the latter to those having the form of *fig.* 6, whence they are termed *lævogyral* or *lævorotatory*. If a dextrogyral plate be superposed on one having a lævorotatory power, and the two be viewed by polarized light, a spiral form will be seen, which is known as Airy's spiral, and is an indication of the compound nature of those crystals which exhibit it. The reader who desires to ascertain more definitely the precise value of the angle of rotation for different thicknesses of quartz, and for different positions of the analyser, will do well to consult a lengthy memoir on the subject by Z. Stefan, in the 50th volume of the 'Sitzungsberichte der Kais. Akad. der Wissenschaften zu Wien' (1865), where also is clearly pointed out the relation between the index of refraction and the angle of rotation of quartz. The methods adopted by the above-mentioned observer are so precise in their indications as to remove some of the objections which have been made to it as a means for detecting the compound nature of crystals.

There is another important process for revealing the structure of crystals, which, although it was employed as far back as 1824, has only lately risen into prominence. It consists in submitting crystals to the slow action of a solvent. By this means depressions are formed upon the surfaces, whose forms and relative positions enable the observer to state what crystalline system the mineral belongs to. If the depressions are similar in form, and arranged in parallel lines, the mineral is of a simple, whereas if they are dissimilar, the mineral is of a compound nature. According to Leydolt, their form is that which belongs to the smallest molecules from whose union the crystal is formed. Leydolt has applied this mode of inquiry to quartz. He used a dilute solution of hydrofluoric acid, and subjected both whole crystals and thin sections thereof to its action. A simple crystal is one in which no rhomb-shaped faces occur to indicate whether it be dextro- or lævorotatory, by mere inspection. When such crystal is subjected to the action of dilute hydrofluoric acid for about twelve hours the following appearances are seen :— First, certain angles will be replaced by the faces *a*, *β*, *γ*, and *s*, and next, well-defined depressions are visible on the faces of the six-sided pyramids. The faces which replace the original angles belong to the rhombohedron, and have four different positions. When developed to their full extent, they give two three-sided pyramids. In *figs.* 7 to 10 the four kinds of simple crystals are represented as they appear after treatment with acid. They were all obtained at Marmaros, in Hungary. These four kinds of crystals Leydolt distingishes as $+r$, $-r$, $+l$, $-l$. In the compound crystals faces sometimes appear at all the angles of the terminating pyramids, or each angle may have one or two faces only, or other modifications may occur depending upon the nature of the crystals, but which we cannot particularize here. *Fig.* 11 represents a compound crystal. The faces of the six-sided pyramid are covered with triangular depressions with bright sides, and arranged in parallel lines, the direction of which vary with each face. Thus, on *R* they are horizontal, that is, parallel with the edge formed by the intersection of the prism and pyramidal summit, while those on *r* are parallel with the edge formed by the junction of *R* and *R*. By this simple process, then, we gain a tolerably clear insight into the structure of any given crystal, and can readily ascertain whether it will rotate the plane of polarization to the right or to the left, or exhibit Airy's spiral, and, indeed, its general behaviour under the polarizing apparatus. Still more precise ideas may be gained by the treatment of plates cut at right angles to the principal axis of the crystal. Thus, if the plate formed part of a compound crystal, its etched surface will be covered with particles having different intensities of lustre. Sometimes there are two shades of lustre, and sometimes four. On examining the surface with a high magnifying power, it appears to be roughened with minute depressions, some of which have an equilateral-triangular shape, while others consist of an amalgamation of two or more of these. The crystalline form and physical peculiarities of quartz appear to be intimately connected with the relative positions of these minute depressions which are supposed to indicate the form of the ultimate particles of the mineral. Leydolt represents all their modes of arrangement in *fig.* 12, where the letters indicate the position corresponding to the various faces or modifications ; $\frac{P}{2}$ means the half of the pyramid, and *R* the rhombohedron ; the other letters have already been explained. In addition to these depressions there are numerous furrows, which are believed to indicate the successive layers which compose the crystal. In an amethyst from Meissau, Leydolt counted from 1400 to 3000 in a line, and estimated that the crystal was found by at least 75,000 hollow superposed pyramids. These facts are important, as showing that the form and physical properties of quartz result from the different way in which its constituent particles are built up. With the light afforded by them the simple statement at the beginning of the article that the alternate faces of the pyramid differ in lustre ; that they are spotted with isosceles triangles ; that the faces of the prisms are horizontally striated ; and that different crystals have opposite rotatory powers, acquire an expressiveness of meaning which they did not have before. Looking also at the opposite position of the particles, and the consequent set of the grain, we at once perceive why quartz shows so few signs of cleavability. Notwithstanding the greater clearness with which well-known facts are invested, we seem to be on the verge of still greater discoveries ; for the student, in this as well as all other branches of knowledge, resembles a man set down in a dim light on an unknown continent. The phenomena within his immediate ken are obscurely seen, and the area of the unexplored district does not appear much larger than that which he knows. When a stronger light appears, not only are the things near him more clearly seen, but the unexplored district beyond becomes proportionally as well as actually larger than the known area. As with the traveller, the visible horizon appears to become more distant in a higher proportion than the intensity of the light ; so with the physical student, the more we know the greater is the apparent extent of the unknown regions. Having ascertained that the ultimate particles of quartz are arranged in a definite way, it is for future inquirers to determine the conditions which bring about the different kinds of arrangement.

Rock crystal, or hyaline quartz, occurs either in crystals and crystalline grains, or as a constituent of crystalline and sedimentary rocks, or as the gangue of metalliferous veins. The crystals are more abundant and more perfect in the older metamorphosed sedimentary rocks than in such as bear unmistakeable signs of having had an igneous origin. Many sandstones are known which are wholly or mainly composed of minute crystals of quartz, as, for example, a sand connected with the lignite formation of Germany, certain portions of the millstone grit, Vosges sandstone, quadersandstein, and the Potsdam sandstone. In some instances the crystals are perfect, and not cemented together, while in others they are more or less imperfect on the sides where they touch each other. They also occur in the drusy cavities of limestones, amygdaloidal rocks, and in the hollows of shells ; indeed, they may be looked for in almost every hollow space, more especially such as are or have been a certain depth beneath the surface. Quartz is more abundant in the rolled, massive, and semi-crystalline states; these are the forms it usually has in sands, sandstones, granites, quartzite, metalliferous lodes, &c., in which it is frequently associated with a white chalcedonic variety. In most cases where both varieties occur together the microscopic examination shows that the white kind has been introduced last, and that the hyaline grains probably represent the original grains of the sedimentary rock. Instances of their association in veins will be found under GOLD, E. C. S., where they are distinguished as vitreous and saccharoid. Quartz is the usual form assumed by silica in the phenomenon termed *silicification*, as also in that known as *pseudomorphism*. No mineral occurs in the form of so many other substances as quartz; thus, according to Bischof, there are 27 such pseudomorphs. He gives examples of the occurrence of quartz and other varieties of silica in the form of calcite, bitter spar, iron spar, calamine, siliceous calamine, cerusite, gypsum, barytine, baryto-calcite, fluor spar, and mica. Amongst others may be mentioned those of celestine, stilbite, heulandite, &c. On the other hand, quartz may itself be replaced by other minerals, such as steatite.

In almost all countries which are rich in metallic ores, the more highly crystalline rocks are traversed either by numerous threads or by thick bands of quartz. The association of quartz with certain metallic ores is so common that it may be said, without much error, that a country rich in quartz veins also abounds in metallic wealth. There are cases, however, when quartz veins contain little or no ore. As an example of a highly silicated country, California is perhaps the best that could be selected, since we know no other that seems to show so clearly all the stages of silicification, and probably few surpass it in the magnitude of its quartz veins. Few, probably, exhibit rocks of cretaceous and even tertiary age which have their indications of sedimentary deposition so completely obliterated by metamorphic action, and yet retain, in the form of highly alkaline hot springs, the agents by which such metamorphism may have been effected. The Pine Tree and Josephine gold mines are in a vein having an average thickness of twelve feet, but in places it swells out to as much as forty feet. In a line with these are other gold mines, which are also situated on enormously thick outcrops of quartz. There is no proof that they are all situated in the same quartz vein, but the fact of their being apparently on the same line of strike seems to lend much support to the view. Some of them are upwards of seventy miles distant from Pine Tree. Near Coulterville a thick quartz vein, supposed to be a continuation of that just referred to, outcrops in the Peñon Blanco or the White Rock, which forms one of the most prominent landmarks of the district, on account of its elevated position and dazzling character. Here it has a thickness of about eighty feet. What appears to be a continuation of the same veins crops out in Tuolumne Co., where it forms the eminences named Whiskey, Poverty, Quartz, &c., Hills. Some of the veins present noticeable peculiarities. Thus not a few have the form of a chimney rather than a vein. One of these in Amador County has been worked to a depth of upwards of 900 feet. The quartz in it is of a grayish-white colour, and interlaminated with seams of soft slate, which have a direction parallel to the sides of the vein. In another quartz vein the mineral had apparently been crushed by the pressure of the overhanging rocks. A vein has also been noticed which disappeared in places and was being replaced by a soft black shale, containing small quantities of quartz in fine powder. At Massachusetts Hill, in Nevada County, a quartz vein has a very flat dip, and seems to form a kind of basin, a feature which has not, so far as we are aware, been noticed anywhere else. The maximum thickness is about 2½ feet, and where best developed the vein is divided into three distinct floors or bands, with several inches of rock between each. In Australia there are some examples of several quartz veins arranged in horizontal layers one above another, but these occur in dykes. [GOLD, E. C. S.] Near Mokelumna Hill, in Amador County, a well-formed quartz vein cuts through one of the superficial gravels, and has, according to Whitney, evidently been formed since the deposition of the gravel by the action of waters holding silica in solution. The mass of the vein is formed of agate and chalcedony, but portions have a ferruginous character. "This," says Whitney, "is not an isolated case; other localities have been noticed where all the conditions necessary to the formation of quartz veins, similar in their general features to those in the auriferous slates, must have existed during the most recent geological epoch." Farther to the east, or near Virginia city, in the Nevada territory, are the celebrated Steamboat Springs, where there is much probability that a quartz vein is in process of formation. The springs are so named from their intermittent action, accompanied by a puffing noise and the discharge of columns of steam. The springs are situated along a fissure, but the water escapes at points somewhat distant from each other. The following passage, descriptive of the deposits formed by them, is from a paper by W. P. Blake ('Q. J. Geol. Soc.,' xx., p. 323). "This mound, some two or three acres in extent, and white as chalk, consists chiefly of silica (siliceous scales) deposited by the water in an amorphous granular state. The deposition in the basin-shaped springs is very rapid, and forms elevated annular mounds. Where the water stands in pools, the silex forms crusts like ice around the edge. In trickling down, it forms stalactites or partly covers the currents running over the slopes. Layer after layer is deposited on inclined surfaces, and some very good examples of the formation of banded agate and chalcedony were seen, the colour being given by oxide of iron and by organic matters, though in general the deposit was white. At some of the springs a thin black film-like oxide of manganese is deposited in the basin where the heat is greatest, while the water that flows away deposits sesquioxide of iron beyond. Neither the specimens of the deposits nor of the water have yet been analyzed. Sulphur is abundantly produced and deposited among the cavities and fissures of the siliceous crust, especially around some of the steam jets when the escape is through the fragments or loose debris of the fissure. It occurs largely in crusts and in small crystals coating the fragments. There are several remains of old basins upon the upper level of the mound where the former overflowing of the springs is evident. These are now cut through by the fissures, so that the water falls to the level of the lower springs and overflows at these only. The new fissure appears to have followed the line of the principal jets; and this change must have taken place within a few years, for the old basins are yet very perfect in form, half being on one side of the fissure, and half on the other. The cracking of the superficial deposits is evidently the result of the widening of the ancient fissure in the rock below. We may regard the whole as a fine example of the formation of a quartz vein along a fissure; for there is little doubt that if the superficial deposits were swept away down to the granite or porphyry, we should find a fissure lined with quartz, and perhaps with sulphurets of the metals."

QUEBEC GROUP. Many years ago a group of rocks in Eastern Canada were described by Emmons as the Taconic system. His observations were based on the strata developed to the east of Lake Champlain, the thickness of which strata he estimated at 20,000 feet. He divided them into an upper and a lower division, and asserted that the ascending order was: (1) granular quartz; (2) the Stockbridge limestone; (3) magnesian slates; (4) sparry limestones; (5) roofing slates (graptolitic); (6) siliceous conglomerate; (7) Taconic slates; (8) black shales. All these, moreover, were said to be older than the Potsdam sandstone, which is, with the exception of the Laurentian limestones, the oldest fossiliferous stratum in America, and equivalent to the Lingula flags of Britain.

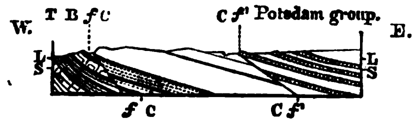
These rocks are the same as those known as the Quebec group, the true age of which has only been established in the last few years. They are largely developed in Eastern Canada, their strike being for the most part north-east and south-west. They form a narrow band, which, commencing at Point Gaspè, skirts the southern bank of the St. Lawrence as far as the Isle of Orleans, from whence the western margin trends southerly, and passes by the east side of Lake Champlain, by Albany in New York, Harrisburg in Pennsylvania, and still farther south. They also cover large areas in New Brunswick, Maine, Nova Scotia, and Newfoundland. Near Lake Champlain they are very much contorted, so that it is difficult to ascertain their true stratigraphical order; but they occur in well-developed nearly horizontal strata along the shore north of Belle Isle Strait, at the mouth of the Gulf of St. Lawrence. They rest on Laurentian gneiss, and form a band about eighty miles long, ten or twelve wide, having a dip of about sixty feet in a mile towards the sea; they are also continued along the shores of Newfoundland. The order of the strata is shown below:—

1. Red and grey sandstones, with *Scolithus linearis*	231 ft.
2. Grey, reddish, and greenish limestones, with *Paradoxides Thompsoni*, *P. Vermontana*, *Obolella cingulata*, &c.	143 ft.
3. White-grained siliceous sandstone	800 ft.

4.	Grey and reddish magnesian limestones, with *Lingula acuminata*	150 ft.
5.	Dark grey limestones	400 ft.
6.	Dark grey magnesian limestones, with geodes of quartz and calcspar. It contains numerous fossils, such as *Bathyurus cordai*, *Leperditia*, *Ophileta*, *Orthis*, &c.	400 ft.
7.	Dark grey magnesian limestone, with *Murchisonia Anna*, *Bathyurus*, *Leperditia*, *Ophileta*, *Orthis*, &c.	130 ft.
8.	Greyish blue limestones, with *Murchisonia Anna*, *Piloceras canadense*, *Bathyurus*, *Leperditia*, *Ophileta*, *Orthis*, &c.	340 ft.
9.	Light yellowish-grey mottled magnesian limestones	150 ft.
10.	Light grey and yellowish-white mottled magnesian limestone, with *Murchisonia*, *Bathyurus*, *Leperditia*, *Ophileta*, *Orthis*, &c.	130 ft.
11.	Light greyish-blue limestones, with *Eospongia*, *Stromatopora*, *Murchisonia*, &c.	130 ft.
12.	Light bluish-grey limestones	550 ft.
13.	Black bituminous limestone	200 ft.
14.	Grey calcareous sandstones, of a somewhat conglomeratic character	700 ft.
15.	Grey, drab, and whitish limestone conglomerates, with *Graptolithus Headi*, *Camerella calcifera*, *Maclurea ponderosa*, *Bathyurus Saffordi*, *Holematopus angelini*, *Endymion Meeki*, *Ophileta*, *Orthis*, *Orthoceras*, &c.	700 ft.
16.	Greenish chloritic sandstones, interstratified red and green shales, probably not under. . .	2000 ft.
		7154 ft.

Of these 1, 2, and 3 may be referred to the Potsdam formation; 4—9 to the calciferous formation; and 14 to 16 appear to represent the strata of this group which occur at Point Levis near Quebec. In this latter district the strata are curved into several undulations, the tops of which have been planed down by denudation. On Orleans Island the Utica and Hudson river formations dip towards the south-east at an angle of about 50°. Resting upon these, and dipping in the same direction and at the same angle, follow the Quebec group. According to Sir W. Logan, these strata have a thickness of upwards of 5000 feet. The real thickness is, however, much less, as the beds are repeated three or four times over. In the lower part they are composed of green magnesian and argillaceous, some of which contain *Graptolites*, interstratified with several limestone conglomerates; and in the upper part of glauconitic beds, grey sandstones, and red and green shales. The limestone conglomerates have yielded numerous fossils. In 1862, 137 species were known, of which 42 were graptolites, 55 mollusks, 36 articulates, and 4 radiates. And since 1862 many more have been discovered. Of these one is known in the Chazy, and nine in the calciferous formation; whilst many others are closely allied to calciferous species. The genera represented by the greatest number of species are *Leptæna* (5), *Orthis* (14), *Pleurotomaria* (7), *Murchisonia* (4), *Metoptoma* (7), *Orthoceras* (7), *Cyrtoceras* (6), *Bathyurus* (8), *Dikelocephalus* (7), *Graptolithus* (29), and *Dendrograptus* (7).

Having glanced at the rocks known to overlie the Potsdam sandstone, let us return to Emmons' section. He knew of very few fossils, but in his No. 5 he found *Triarthrus Beckii* associated with *Graptolites*. As far as is yet known, *Triarthrus Beckii* is restricted to the Utica formation in Canada, and it is known to be frequently associated with graptolites, a fact which at once suggests a doubt as to the age assigned to the rocks. His evidence, however, mainly rested on stratigraphical evidence, and the circumstances under which the Quebec group and older rocks occur together, are certainly apt to mislead, as will be seen by referring to the following section, which represents a phenomenon commonly met with along the western outcrop of the Quebec group. The rocks dip towards the east; a person working from the W. would soon discover that in passing from T to the first C, the easternmost strata were the newest; as the strata between this point and the E. end of the section also dip towards the east, it would naturally be inferred that the strata beyond *f*′ were the most modern. Further researches would show that the existence of the faults and of the overlaps renders this inference incorrect. The strata examined by Emmons are brought into a similar position by faults and overlaps.



T, Trenton group; B, Black River group; C, Chazy group: *f*, fault: *f*′, overlap; L, level of Lake Champlain; S, level of sea.

R

RADIOLARIA. [Foraminifera, E. C. S.]

RAISED BEACHES [Beaches, Raised, E. C. vol. i. cols. 400, 401; Post-Pliocene Period, E. C. S. cols. 715—717]. The term beach is applied to the detrital material which accumulates at the highest margin of all waters subject to periodical ebbs and flows. A sea-beach, then, marks the line or band up to which the high tide usually reaches. When this line remains at nearly the same level for a long period the quantity of shingle collected is considerable. Under favourable conditions, such shingle deposits may be preserved for a long period. As such beaches are always formed at the high tide level, and as many are now to be found above that level, they indicate to us the changes which the land has undergone with respect to it. These changes are of two kinds, viz., changes in the local heights of tides, and changes in the height of the land relatively to the sea level. The elevation of a beach above high-water mark is, then, due to two different sets of causes. By the one set the water leaves the beach owing to the readjustment of high-tide level; and by the other the beach leaves the water, owing to the upheaval of the land. Geologists, however, rarely distinguish the two kinds of elevated beaches, but call them all raised beaches. The beaches which have been left high and dry without alteration of level have generally been formed above the mean level of high-water mark, and have become exposed by local alterations in the outline of the land, whereby the waves which were compressed into a narrow space are allowed to spread out more freely. A raised beach implies that the land itself has been elevated; but as the amount of uplift varies with the locality, it is sometimes exceedingly difficult to determine how much of the height above the sea is due to elevation, and how much to local recession of the high-water mark. For similar reasons, it is not always easy to say whether two raised beaches on nearly, but not quite the same level, are contemporaneous, or whether the higher is older than the lower. Again, difficulties arise from the circumstance that the land oscillates in level, and that occasionally a beach may be formed on nearly the same horizon as another which had been formed at an earlier period when the land and sea were similarly related as to height.

As beaches have been formed at all heights of the land, we may expect to find them at any level; but owing to the more extensive denudations which the higher lands have undergone, raised beaches are far more abundant near the present level of the sea margin than far above it. At the lower levels also they form less disconnected lines than at the higher, and thus enable us to determine their contemporaneity with greater certainty. Round the British Isles, but especially on the west coast of England, Wales, and Scotland, there is a conspicuous line of beaches at from 30 to 40 feet above the sea. Beaches generally mark the height at which the land remained comparatively stationary, and along this 40 feet line we have an immense accumulation of detrital matter and numerous caves. This lower line of beaches is the most recent, and yet it is evidently of great age; for no satisfactory evidence has been adduced to show that any upward movement has taken place since the time of the Romans. At the highest levels the beaches are so few and so scattered that it is difficult to group them into periods. At present we propose to mention a few only of the highest. Along the rocky shores of North Wales is an old coast line between 200 and 300 feet above the sea level, marked by a continuous line of rounded projections and recesses modelled by the waves. Near Llandudno, and in one of the caves, is a shingle beach formed of precisely the same material as the one in process of formation. At Great Orme's Head a similar beach exists 400 feet above the sea. Near Buxton there is a still more remarkable case. We there have a broad valley, bounded on the west and north by Axe Edge, Burbage Edge, Long Hill, and Black Edge; and on the south by the lower range of hills of which Harper Hill forms a part. In this valley is a limestone ridge, having a north-westerly and south-easterly direction. Its highest point is a prominence known as "the Tower," forming a portion of Grin Edge, and rising to an elevation of 1435 feet above the sea. Opposite to it is Harper Hill, having about the same height. The hills are covered by a thin layer of turf, clay, and sand; and when this is removed for the purpose of quarrying the limestone, the surface of the rock presents all the appearance of a beautifully preserved sea-beach and shore. The limestone is worn into holes and cavities of the most fantastic form, some of which are filled with pebbly shingle. At the lower edge of this shore is a line of bold craggy rocks, at the base of which is a limestone terrace supporting large blocks of stone, and worn into holes, just as is frequently to be seen at the low-tide level of rocky shores at the present day. Here we have the whole space exposed from the high-tide beach to the low-tide margin. The craggy cliffs and rough rocks are repeated at intervals to the bottom of the valley, but not the shingly beach. The height of this beach is about 1435 feet above the sea, and it can be traced as a narrow fringe along the hill sides for fully half a mile. When standing on Grin Edge, and looking across the valley, a similar line is distinctly marked on a level with the eye along the upper slopes of Harper Hill, and there also a similar beach has been discovered. From their being on nearly or quite the same level, it is believed they were contemporaneous formations. They seem to have undergone little alteration, from having been protected by a covering of white clay. These high terraces bear testimony to the great depression of the land during the post-pliocene period, and to the enormous uprise which has since taken place. In Ireland there are many lines of escarpment at considerable heights, and on some of them are raised beaches. In Yar-Connaught, seven sets of sea margins have been observed at heights comprised between 130 feet up to 1070 feet. In Slieve Aughta they rise up to 1240 feet. In Canada thirteen sea margins have been detected at heights varying from 342 up to 996 feet. Similar phenomena are observable in many other countries.

RAPHIDES [TISSUES, VEGETABLE, E. C. vol. iv. col. 1073]. This name is given to the mineral accretions which are developed, sometimes abundantly, and sometimes sparingly in the cells of many plants. One of the later authorities on the subject is Professor Gulliver, who treated it at considerable length in a series of papers in the 'Annals and Magazine of Natural History' for 1863. He indicates that while some orders of plants are raphiferous, others do not develope raphides; but he pushes his inferences too far when he insists that such a character should be regarded as of universal and fundamental importance in systematic diagnoses. Another group of bodies similar to the above may be here mentioned, viz., *cystoliths*. These are principally collected together in certain cells in or near to the epidermis, but occasionally they occur in the deeper seated cells. They are formed largely of cellulose, mingled with various proportions of carbonate of lime. In their earliest stages they are suspended by filaments of cellulose. Their shape varies, but is frequently characteristic of a genus. Thus in *Ficus* they are ovoid; in *Pilea*, Y-shaped, and in a few horse-shoe formed.

RETICULOSA [FORAMINIFERA, E. C. S.].

RHÆTIC BEDS. In the neighbourhood of Bristol and in several other districts of the West of England there occur a series of strata with peculiar fossils above the red marls of the Keuper, and beneath the calcareous deposits of liassic age. The strata pass gradually downwards into the Keuper marls, but there is a break of variable extent between the uppermost Rhætic and the lowermost liassic beds. The red marls below pass by degrees into greenish marls, which are followed by black papery shales and thin bands of tough greyish limestones quite different in appearance from those of the liassic series. The most abundant Rhætic shells are *Pecten valoniensis*, *Modiola minima*, *Pullastra arenicola*, *Cardium rhæticum*, and others. All these are rare, or absent in the lowest liassic beds, in which *Ammonites planorbis* and *Ostrea liassica* occur in immense numbers. Although the Rhætic beds are generally of inconsiderable dimensions, they have been detected in many parts of the Continent. Thus they are met with all through Germany, Norway, Sweden, Bohemia, Hungary, Lombardy, and the south-east of France. In the north it is generally thin, but its thickness increases towards the south, so that in Lombardy and the Alps it constitutes whole mountains. Wherever exposed it abounds in organic remains; the *Avicula contorta*, the bones of fishes and reptiles, and numerous individuals of *Gervillia* and *Pecten*, characterise it throughout its range; while in England on the west, and in Wurtemburg on the east, mammalian remains have been met with. But although it is characterised everywhere by a few common associated species, the lithological and palæontological features are by no means uniform. Considerable diversity in the nature of the strata and in the composition of the fauna is detected wherever any large area is thoroughly explored. In the south calcareous deposits prevail, while in the north and in the west arenaceous strata form a considerable proportion of the thickness. Where it is most sandy and thinnest it is accompanied by its remarkable "bone bed," which is absent where the series is most calcareous and thickest. On the Continent, as in England, it is conformable with the Keuper, but unconformable with the lias; so that it is a triassic rather than a liassic group, contrary to what was the prevalent opinion some time back, when these beds were placed in the lowest part of the lias.

In addition to the species mentioned above as common in the Rhætic beds, the following are of general occurrence:—*Gervillia præcursor*, *Anatina præcursor*, *A. Suessi*, *Schizodus præcursor*, *Lima præcursor*, *Leda percaudata*, *Sargodon tomicus*, and *Acrodus minimus*. The palæontological differences may be roughly indicated by referring to the local development of corals in the Alps and in Western England; to the restriction of *Gervillia inflata* to the Alps; to the numerous species of *Equisetaceæ* and *Cycadeæ* found in Germany only, and, as already noticed, to the limited area of the bone bed. We have spoken of the bone bed as though it were a single stratum. Many geologists are or have been of this opinion, but there is no question that at some localities two or more bone beds are met with on nearly the same horizon; so that it is premature to assert that the same bed is found at all. The layers of bones usually mark surfaces which have remained for a long time without additions of material, and which frequently present more or less unconformability to the next stratum.

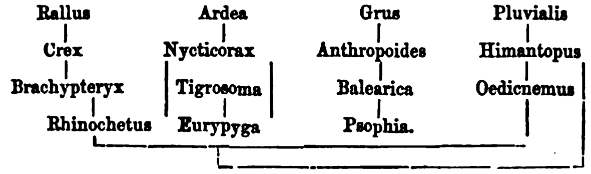
The Rhætic beds are especially remarkable for being those in which the as yet earliest known mammalian remains have been found. In 1847 the bone bed at Diegerloch in Würtemberg yielded the marsupial genus *Microlestes*; in 1858 Mr. Moore found teeth of the same genus, as also of others not yet named, in a fissure of the carboniferous limestone filled with Rhætic breccia; and in 1861 Dawkins discovered teeth of *Hypsiprymnopsis rhæticus* in a low part of the series near Watchett, so low that this last is the oldest mammalian species discovered.

Sections of the Rhætic beds can be studied at East Cliff and Westbury on the Severn; at Watchett, Pyle Hill, Beer Crowcombe, Long Sutton, Shepton Mallet, and Saltford in Somersetshire; at Penarth (from which locality the group is frequently known as the Penarth beds) and Patchway in South Wales; as also in the railway cuttings at Hatch Beauchamp, Willsbridge, and Newbridge Hill.

RHINOCHETUS. A genus of birds, of which but one species, *R. jubatus*, is known. It is an inhabitant of the little-known island of New Caledonia, the natives of which call it the kagu, and catch it for the sake of its flesh. The French, who have lately colonised the island, also consider it to be excellent eating, and large numbers have consequently been killed. From these and perhaps other causes this bird, which was at one time plentiful near Port de France, is becoming so scarce that it is now very difficult to procure live specimens. They frequent small marshes and ponds, more especially those in the interior of the island, and feed upon worms, slugs, &c.

In 1862 a specimen was received at the Zoological Gardens, Regent's Park. It was quick and lively, and delighted in running after and driving about the water-hens which were in the same inclosure with itself. Occasionally it varied its frolics by catching hold of its tail with its beak and pirouetting in a curvilinear track, or by throwing about and chasing a piece of paper or a leaf; or by thrusting its bill into the ground at the same time that it spread out its wings, kicking its legs into the air, and tumbling about as if in a fit. In searching for its food it examined every corner and cranny for snails and worms. In catching the latter it struck the ground two or three times with its foot, then suddenly darted its bill into the earth, pulled out the worm, and with a shake swallowed it. A pair of these birds which were living in the Botanic Gardens at Sydney are thus described by Dr. G. Bennett:—"The female is a fine bird, and the largest specimen of the kagu I have yet seen. It is graceful and elegant in appearance, active and lively in its habits, and its plumage in excellent condition. It is distinguishable from the male bird by its much larger size and by the light colour of its plumage, as also of its bill, feet, and legs. She has, besides, a peculiar habit of crouching on the ground, and covering herself with her wings by throwing them over together in a concave form, completely concealing the head and body. The male bird, on the contrary, threws up his wings alternately, as if using them as shields, and displays much pugnacity. The latter differs in colour from the female, his plumage being dark brown, with bars of a lighter shade; the primaries and secondaries of the wings are very dark brown, barred with black; the crest is also of a much darker shade of grey than in the female; the back and legs are of a bright orange red colour. When seen together, the male appears small, compared with the female. The latter utters a growling kind of scream, while the male makes a noise between a bark and a laugh, which is difficult to express in words, terminating in the oft-repeated note of ŏŏ, ŏŏ, ŏŏ, ŏŏ. The male bird is very lively, and readily attacks its aggressors." The male died, and its skeleton was sent to Mr. Parker, and formed a valuable aid to that gentleman in drawing up his memoir on the osteology of the species.

But the especial interest attaching to this bird is its anatomical structure, which combines the features which are elsewhere separated amongst the herons, cranes, rails, and plovers. On the whole, however, it seems to be most nearly allied to the *Ardeidæ*, and is more like the *Eurypyga* than any other bird. The broader down tufts, which are highly developed amongst the *Ardeidæ*, are unusually well displayed in *Rhinochetus*. The tufts cover nearly the whole body, and the quantity of white powder which is formed is so great that when the bird dips into the pond the surface of the water is covered with a white film. In Mr. Parker's memoir already alluded to, the complex affinities of the species are pointed out, and notwithstanding his careful investigation, he is unable to say whether it is most of a crane, a night heron, or a wingless rail. The affinities of the genus are thus indicated by him:—



(Bartlett, Parker, and Bennett, in the *Proceedings of the Zool. Soc. for* 1862, 1863, 1864.)

RHYNCHOCEPHALUS [SPHENODON, E. C. S.].

ROCKS. The following is a rapid outline of the principal technical terms used in describing the appearance and position of rocks. Every rock is made up of a number of particles which vary greatly in size. When they are large enough to be seen by the naked eye the rock is said to be *granular*, and when they cannot be thus distinguished it is said to be *compact*. This term is also, and more commonly, used in reference to a rock that is firm or well consolidated. The size and shape of the particles being variable, other terms are required to express the more important differences; when they are very small, of appreciably the same size, and semi-crystalline, the term *granular* is more especially restricted to them, as, for example, saccharoidal or granular limestone, and some granites; when the crystalline particles are somewhat larger the rock is *granitoid*, as in syenite, &c.; and a still further distinction may be effected by calling them fine, medium, or coarse-grained. When the mass is made up of markedly unequal-sized crystalline particles we have the *porphyries*. The rocks which have large crystals scattered throughout a compact matrix are the *porphyries* properly so called, while such as have large crystals combined with a granular matrix are termed *porphyritic;* the latter is more especially applied to those cases in which the large crystals are felspar, hornblende, or augite, special names being frequently used when other crystals occur, as, for instance, *garnetiferous*, when they are composed of garnets; *pyritiferous*, when of pyrites; *staurotidiferous*, when of staurotide, and so on in several other instances.

When the rocks are not crystalline the particles are either rounded and water-worn or angular. The former character is more especially characteristic of sedimentary rocks, and the latter of such as have been formed by glaciers and other subaerial agencies. Confining our attention for the present to the first group, we have *sands* when the particles are small, loosely aggregated, and composed of silica; if, as is usually the case, it is the quartz variety of silica, the term *arenaceous* is used. If the particles are cemented together they form a *sandstone*; and if the small particles are intermixed with small pebbles the rock is known as a *grit*. When the particles are small, loosely aggregated, and composed of carbonate of lime, we have *ooze*, which when hardened or compressed passes into *limestone*. When the material is silicate of alumina the soft moist substance forms *mud*, which when drier and firmer becomes *clay*, and when still further hardened so as to break with a peculiar fracture it is termed *argillite* or *clay-slate*. Generally the different kinds of material are mingled, and the rocks are then termed *calcareous* when carbonate of lime is the principal secondary ingredient; *argillaceous* when it is clay; *micaceous* when it is mica; and *ferruginous* when it is oxide of iron. In some cases these modifications have special designations. Thus a highly arenaceous clay is called *loam*, and a clay rich in calcareous matter is called *marl*. If a rock is formed of rounded stones it is a *gravel*, when it occurs on the surface of the land or interbedded amongst other rocks, and *shingle* when collected at the margin of the sea. When the pebbles are cemented together they constitute a *conglomerate*, some of the darker varieties of which are occasionally called *puddingstone*. A *breccia* is a similar kind of rock, only the fragments are angular.

As amongst the crystalline rocks so amongst those of sedimentary origin there are minor differences relating to the particles themselves. In many cases the appearances we allude to are apparently caused by some peculiar action analogous to crystallisation, that is to say a force which brings together particles of a similar chemical nature, and moulds them into definite shapes. The kind of structure to which they give rise may be conveniently called in the aggregate a *concretionary* structure. In many limestones the rock is more or less made up of minute spherical grains. When broken these grains exhibit sometimes a compact structure, and sometimes a concentric, radiated, or cavernous one. The size varies from extreme minuteness to globular masses three or four feet in diameter. When they are about the size of a millet seed the rock is said to be *oolitic*, as in the limestones of the oolitic formation; when they are about the size of a pea they are called *pisolitic*. An oolitic-like structure is met with in some of the volcanic rocks, such as pearlstone and basalt, and is usually called *spherulitic* or *globuliferous* when the grains are nearly round; *nodular* when they are somewhat elongated and numerous, and *spotted*, *variolitic*, or *pock-marked* when they are somewhat scattered. *Septaria* are lenticular concretions which have been cracked, and the spaces thus formed been filled up with calcspar, brown spar, or iron spar. As these materials are somewhat harder than the main part of the septarium their outer rims appear as a kind of prominent net-work with, generally, pentagonal meshes. When the concretion is hollow and the interior lined with crystals it is called a *geode*, a term which is also applied to hollow crystal-lined pebbles which may or may not have been formed by concretionary action. Sometimes a small concretion lies loose within the hollow of a larger one, so that it rattles when shaken, and is hence called *clapperstones*.

In addition to the cavities in concretions rocks may have others between the particles. When such cavities are minute and more or less angular the rock is said to be *porous*, as in many sands and sandstones, and indeed all rocks which allow of the percolation of water through their substance, as contradistinguished from such as only allow the water to pass through by means of open passages. When the cavities are rounded and larger than those indicated by porosity, we have the *vesicular* condition, which may receive other names according as the cavities or particles occupy the most space. When the cavities are few in number and scattered the term *vesicular* is especially applied to such rocks; when the cavities and solid parts occupy about equal spaces the rock is *scoriaceous;*

and when the cavities predominate it is *pumiceous.* The shape of the cavities may vary through all kinds of regular and irregular sphericities, such as spherical, lenticular, pear-shaped, nodular, &c. Sometimes these cavities have been partially or wholly filled up by various kinds of crystals, such as quartz, zeolites, &c., or by layers of semi-crystalline matter, in all which cases the rock is described as *amygdaloidal* [AMYGDALOID, E. C. S.].

We will next proceed to the terms descriptive of the appearances in the rock masses themselves rather than of the particles which compose them.

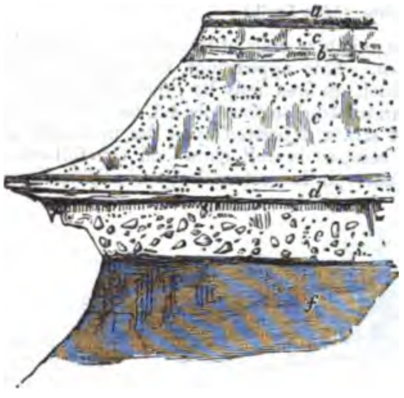


Fig. 1.—Section at Compton Bay, Isle of Wight. *a*, soil; *b*, iron-stone; *c*, sand; *d*, sandstone; *e*, gravel; *f*, shale. (After Bristow.)

A stratified rock mass is divided by a number of lines into a number of portions varying in size. Originally each rock was a sediment strewed over a surface which was horizontal or nearly horizontal. Confining our attention for the present to the lines parallel or approximately parallel to the originally horizontal surface we should notice in examining any section exposing a side view of a stratified deposit, such as a quarry, railway cutting, cliff, &c., a number of layers ranged one above another, and, if the section be deep enough, composed of various kinds of materials, such as sand, carbonate of lime, clay, &c. To this kind of arrangement the term *stratification* is applied, and an example of it is given in *fig.* 1, which represents a portion of the cliff in Compton Bay, Isle of Wight. The order, descending from the top, is soil, sand, iron-stone, sand, sandstone, gravel, and shales. Each of these, with the exception of the iron-stone, is a *stratum.* In addition to the horizontal lines bounding the upper and lower surfaces of each stratum, there may be noticed in the sandstone a middle line dividing it into two parts. When there are a number of these divisions it is usual to call each one a *bed;* and according as they are few or many inches thick the stratum is said to be *thin bedded* or *thick bedded.* The shale is sub-divided into many minute divisions, each of which is commonly called a *lamina,* while rocks of this nature are said to be *shaly* or *laminated. Seam* and *band* are applied to thin layers of one material, generally coal, iron-stone, or quartz, interbedded amongst a thick stratum of some other material. In cases where the band is thick it is called indifferently a bed or a seam. In some schists and in gneiss there is an appearance very similar to lamination produced by the different materials of the rock, generally mica, quartz, and felspar, being collected separately into thin laminæ. This, it will be noticed, is somewhat different from ordinary lamination, in which one lamina resembles another in composition, whereas in gneiss, &c., there is a certain amount of distinction in the composition of the laminæ. This appearance is called *foliation* or *schistose.*

The various laminæ in a bed are not always deposited horizontally one over another, but are occasionally arranged in a slanting direction. By some authors this is called *compound bedding,* and by others *false* and *cross bedding.* There are several varieties of false bedding, each of which is indicative of a peculiar method of deposition. The simplest is that shown by the beds *b* and *d* in *fig.* 2, which, it will be seen, are composed of laminæ regularly arranged, but sloping towards the lower face of the bed. In *b* the slope is in one direction, while in *d* it is in the opposite. This structure is frequently called the *ebb and flow structure,* and generally arises from the action of an ebbing and flowing current, such as a tidal wave. But it may also result from fluviatile action, as exemplified in *fig.* 3, which represents the section of a sand-bar, two miles above Wayne city, on the Missouri river. A more complicated variety is the *beach structure,* in which there are seldom any traces of parallelism, of bedding, or of lamination, and in which the beds rapidly thin out or alternate from sand to gravel. An example of this is represented in the following section, *fig.* 4, by the gravel beach 5, which is now 25 feet above the present level of the sea. The *sand-drift* structure is still more confused and irregular. The subordinate parts are laminated, but there is an almost entire absence of anything like stratification, as is well shown in *fig.* 5.

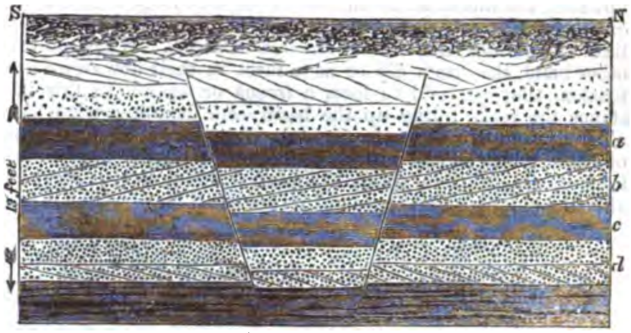


Fig. 2.—Section of Barnwell gravel-pit. (After Seeley.)

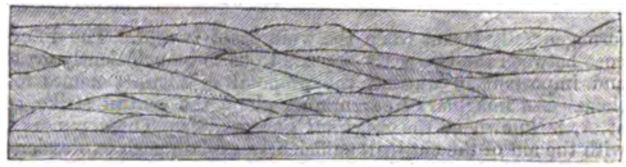


Fig. 3.—Section of a river sand-bar, showing the false bedding. (After Swallow.)

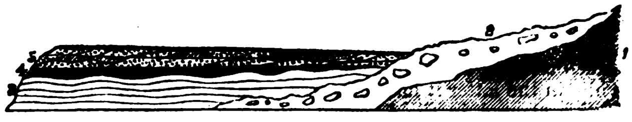


Fig. 4. (After Jamieson.)

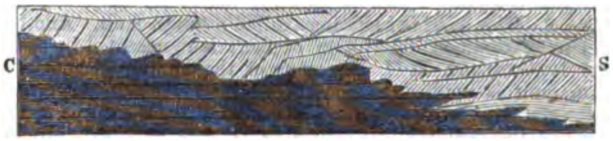


Fig. 5.—Section showing a deposit of sand, having the sand-drift structure, in a valley scooped out of coal. S, sand. C, coal. (After Jukes.)

In all these cases, excepting that of the sand-drift structure, there is reason to believe that the strata were originally nearly horizontal. This may not always be at first sight apparent in the beach structure, but it is perceptible if attention be given to the stratum rather than to the beds or laminæ. Under the influence, however, of various elevatory and depressing forces acting within the earth's crust, these horizontal strata are, sooner or later, liable to be tilted up, fractured, or bent, so as to give rise to the phenomena which will next engage our attention.

When the land is uplifted or depressed unequally, the strata necessarily take a sloping position relatively to the horizon. This slope of the strata, as represented in the groups of beds numbered 1, 2, 3, 4, in *fig.* 6, is called the *dip.* Its amount is indicated by the angle which it makes with the plane of the horizon or sea-level, and its direction by the point of the compass towards which the slope may be. Thus at Turin the dip would be about 10° and the direction north-west. The line at right-angles to the dip is called the *strike,* and although there may also be a slope in this direction, there is not, so far as we

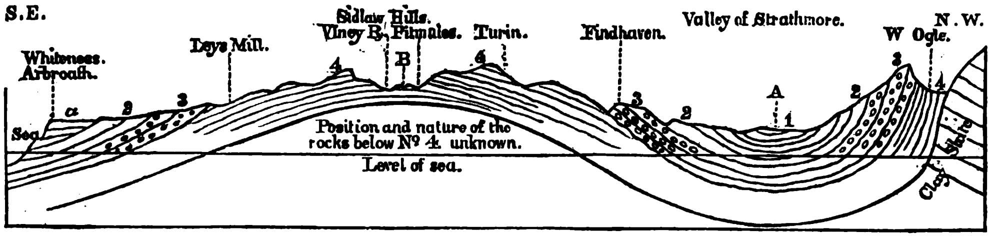


Fig. 6.—Section of the Old Red Sandstone of Forfarshire. (After Lyell.)

are aware, any technical term to express it. When the strata dip in opposite directions so as to meet in a ridge when prolonged upwards, the line or strike running along this ridge is called the *anticlinal line* or *axis:* B, *fig.* 6, marks the position of such a line. The ridge itself forms an *arch* or *saddle.* When, on the other hand, the strata dip so as to meet in their downward extension, they are said to form a *trough* or *basin.* In this instance the rocks filling up the basin were deposited when the older stratum, No. 4, was horizontal. But there is another form of basin, which should not be confounded with the kind above noticed, viz., that in which the central strata were deposited after the older rock had assumed its synclinal form. This is the form generally meant when the word basin is used. The difference between the two cases appears to us to be sufficiently great and important to warrant the proposal of distinct names for them. An imaginary line running along the central strike, as at A, is known as the *synclinal line* or *axis.* These remarks, with the aid of the cut, will sufficiently explain such expressions as tracing a bed until it is taken down by a synclinal at W. Ogle (see *fig.* 6), and is brought up again a few miles off at Findhaven by an anticlinal, and then, bending over the arch, disappears with a dip of 12° towards the south-east. Instead of one bend, as shown in the figure, there may be a series of them within the space of a few miles. These are termed *folds* or *undulations.* When the beds dip in several directions from a central point it is called *quâquâversal;* it is exemplified in many volcanic cones. The folds themselves may present variations in character. Thus their two slopes may have equal or unequal dips in contrary directions. In the former case the *axial plane* is perpendicular, while in the latter it has a dip in a certain direction. Examples of this abound in the Appalachian range, where the rocks are thrown up so as to resemble a grand system of waves solidified in the act of turning over, and with their crests more or less denuded. During the process of elevation and depression, the rocks are not only bent into folds, but are frequently fractured, and the beds are either simply disjoined or the direction of their several parts is entirely altered. This dislocation in the vertical direction is a *fault,* which is shown in one of its simplest forms in *fig.* 2. This kind is sometimes called a *trough* fault. Another and more common description of fault is represented in *figs.* 8 and 10, GEOLOGY, E. C. In many of the mining districts the term fault is applied to almost anything that interrupts or deteriorates a bed of coal. Thus a sandbank occupying the place of the coal, such as shown in *fig.* 5, is so called by some miners; as also a dyke of intrusive rock cutting through the coal, and even an outcrop of the coal bed. None of these phenomena have any connection with faults, although the sandbank is termed *rock fault* by the officers of the Geological Survey. The strata displaced by a fault are either pushed upwards or let downwards. In the former case they are said to have undergone an *upthrow* of so many feet, or yards, or fathoms, and in the latter a *downthrow.* No amount of tilting and faulting will produce the appearance now presented by the uppermost surfaces of rocks. This is brought about by the action of the sea during their gradual elevation above its level, and by that of rain, rivers, and atmospheric influences when they are above that level. These agents wear down the rocks partially by dissolving away the material by which the particles are cemented together, and partly by rubbing off the particles themselves. These fall into the rills, rivulets, and rivers, and are carried to a lower level, sometimes a few yards, sometimes a few miles, and sometimes into the sea. This degrading process is called *denudation,* and it is by this process that all the main outline features of the land are produced. Thus in *fig.* 6 it may be noticed that the beds of stratum No. 4 are rendered discontinuous in consequence of portions of them having been scooped away, while extensive lengths of the strata numbered 2 and 3 have entirely disappeared. This has been effected by denudation. Hence by the continued action of this force and of upheaval the fragmentary ends of the strata 4, 3, and 2, are exposed at the surface. This appearance is known as *outcropping* or *bassetting.* Such an area may be gradually submerged beneath the sea, the undulating surface planed level by the waves, and a fresh series of strata deposited upon the upturned edges or outcrops of the beds, as is well shown in the following sketch of Grace Dieu quarry, in Leicestershire (*fig.* 7). The dip of the strata *c* and *b* are nearly the same, while the beds of *a* do not dip at all. Whenever the beds of a connected group of strata harmonize in position, that is, are parallel to one another, they are said to be *conformable,* but when there is a want of harmony in their planes of extension, they are said to be *unconformable.* Thus there is an unconformability between *a* and the beds *b*, *c*. There is also an unconformability, although slight, between *d* and the bands of limestone above it. The unconformability indicates a pause of variable duration in the depositing agents. Sometimes the time that has elapsed between the cessation and recommencement of the process may have been comparatively short, in which case the materials below and above the line of unconformability are generally nearly alike. In other cases the time that has elapsed has been so great that the lower strata have been upheaved and tilted from their original position; the upper strata are widely different in the nature of the materials forming them, indicating a considerable alteration in the relations of the depositing agents towards that particular spot; and the fauna which preceded the formation of the line of unconformability differs from that which immediately succeeds it. When the changes are sufficiently well marked, the unconformability is said to mark a *break* in the order of deposition and in the succession of life.

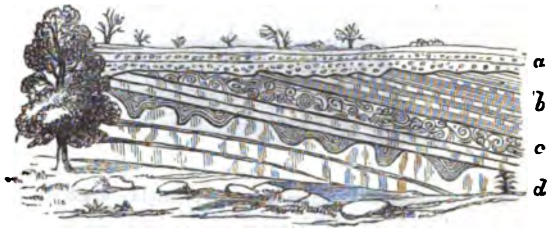


Fig. 7.—Section at Grace Dieu quarry. (After Hull.)

S

ST. CASSIAN BEDS. A group of strata belonging to the triassic formation, which has yielded at St. Cassian in the Tyrol a remarkable assemblage of fossils, both as regards character and number. This local fauna has been carefully studied by Munster, Klipstein, Laube, and others, and now comprises upwards of a thousand species. In these beds some of the palæozoic genera appear to come to an end, and in them we find some genera commence, which ascend far up into the liassic series. Hence the fauna links on the palæozoic with the mesozoic life.

SALMONIDÆ [E. C. vol. iv. cols. 652-654]. Whenever an eminent zoologist concentrates his attention upon a group of animals such as a genus or small family, it almost invariably happens that he sweeps away a portion of the cobweb of errors that had collected about it, places old facts in a new light, and gives the new facts acquired by himself a more interesting aspect in consequence of the partial insight they afford us of the existence of some of the hitherto undiscovered laws which regulate the affairs of animals. One illustration of this is afforded by Dr. Albert Günther's recent contributions to the knowledge of the British charrs.

The genus *Salmo* is divided by him into *Salmones* or the salmons proper, and *Salvelinii* or the Salvelines. The latter group embraces the charrs, which are remarkable for being distributed in all the deep lakes of the northern hemisphere, and for the apparently restricted range which some of the species have. Some are only known to exist in a single lake; and it would almost seem that not a few are on the verge of extinction. It has generally been supposed that there are three British species of charrs identical with those named by Linnæus,—*S. salvelinus*, *S. umbla*, and *S. alpinus;* but Dr. Günther shows that *S. alpinus* is the only Linnæan species which has yet been found in Britain. The *S. salvelinus* of Linnæus was the name given to a German fish, which is still known as the *Sälbling* in various localities. The British specimens assigned to this species have a much narrower head, a much larger eye, and a far larger pectoral fin than the German representatives. Accordingly, Dr. Günther decides they are not specifically identical; and that, therefore, the British specimens do not belong to *S. salvelinus*. He also gives his reasons for believing that the British specimens referred to *S. umbla* do not belong to the same species as the specimens thus named by Linnæus. He passes in review the researches and opinions of the various ichthyologists who have treated of this group, from Willoughby in 1685 to Yarrell in 1841; and endeavours to point out the errors into which the most of them fell. Agassiz and Thomson considered that all the charrs in Great Britain and Ireland belonged to but one species, which species was subject to extraordinary variety. Without denying that they may be varieties of one species, Dr. Günther avers that neither of the two above-mentioned eminent observers have given any details to prove their position; and that, therefore, we ought to take the species as they are. Dr. Günther lays down a good foundation for future enquirers, by carefully describing each well marked form. The charr of Windermere is termed *S. Willughbii;* the Torgosk of Llanberris, *S. Perisii;* the freshwater herring of Lough Melvin, *S. Grayi*. A number of specimens collected from Lapland, Orkneys, and Scotland, were referred by Dr. Günther to *S. alpinus;* but he points out that there are certain differences between the specimens of different areas which may require their specific separation at some future time. For example, the Lap specimens attain their maturity when from twelve to thirteen inches long, while those of Scotland are mature when only nine inches in length. The Scotch specimens are not identical with the *S. alpinus* of Lapland, but may belong to a variety of it. This variety is found in Lake Helier in Hoy, Orkneys, and probably certain other lochs in Scotland. *S. colii* is the name for a species from Lough Eske. It is smaller than the foregoing, attaining maturity when five inches long. Dr. Günther's conclusions are:—

1. That three very distinct species of charrs are found in Great Britain, namely, *S. Willughbii* in Lake Windermere and Loch Bruiach; *S. Perisii* in Wales; and *S. alpinus* in certain parts of Scotland.

2. That these three species differ, by most constant characters, from the *S. umbla* and *S. salvelinus* of the Continent; but that *S. alpinus* of Scotland is closely related to the *S. alpinus* of Lapland, differing merely by its smaller size when first attaining to maturity, and by the number of vertebræ.

3. That Iceland is inhabited by a distinct species, *S. nivalis*.

4. That the charrs of Ireland form a separate group by themselves, distinguished by the feeble development of their dentition; and that the charr of Lough Melvin (*S. Grayi*) is a distinct species from that of Lough Eske and Lough Dan (*S. Colii*).

A few of the principal distinctive characters of the mature individuals is given in the following synoptical list:—

I. Jaws well developed; teeth of moderate size.

A. The length of the pectoral fin in the mature fish less than one-half of the distance between the roots of the pectoral and ventral fins.
   1. Thirteen dorsal rays. Intermaxillary teeth much stronger than those of the maxillary. Lateral line formed of 185 scales. Lower parts silvery. *S. umbla.*
   2. Fourteen dorsal rays. Intermaxillary and maxillary teeth equal in strength. Lateral line formed of 190 scales. Lower parts red. *S. salvelinus.*

B. The length of the pectoral fin in the mature fish more than or equal to one-half the distance between the roots of the pectoral and ventral fins.
   1. The height of the body one-fifth or one-sixth of the total length; the height of the dorsal fin three-fifths or one-half of the entire length of the head. Lateral line formed of from 195 to 200 scales. *S. alpinus.*
   2. The height of the body one-fifth of the total length; the height of the dorsal fins equal the length of the head without snout. 190 scales in the lateral line. The gill cover not overlapping the root of the pectoral. *S. nivalis.*
   3. The height of the body one-fifth or one-sixth of the total length; the height of the dorsal fin two-thirds of the length of the head. 170 scales in the lateral line. The gill cover overlapping the root of the pectoral. *S. Perisii.*
   4. The height of the body one-fourth of the total length; the height of the dorsal fin equals the length of the head without the snout. 165 scales in the lateral line. The gill cover not overlapping the root of the pectoral. *S. Willughbii.*

II. Lower jaw very feeble; teeth minute.

1. The pectoral extending to or beyond the origin of the dorsal fin. *S. Grayi.*
2. The pectoral terminating at a considerable distance from the origin of the dorsal fin. *S. Colii.*

Of the Salmons proper, Dr. Günther recognises 11 British species, viz.:—

a. Migratory species.

S. salar, True Salmon of British rivers.
S. cambricus, "Sewin" of South Wales.
S. trutta, Sea Trout of Scotland.

b. Non-migratory species.

S. fario, England.
S. Gaimardi, Scotland and North-West England.
S. nigripinnis, mountain lochs of Scotland and Wales.
S. levenensis, Loch Leven, Scotland.
S. ferox, Great Lake Trout of Scotland and Wales.
S. orcadensis, Lakes of Orkneys.
S. brachypoma, Frith of Forth.
S. stomachicus, Ireland.

In 1865 another Scotch species was described under the appellation of *S. Killinensis*. It was obtained from Loch Killin, Invernes-shire, and by its character seems to belong to the Irish group. Its lower jaw is feeble, and its teeth very small; but it is most distinctively marked by the great length of its pectoral fins.

SANDSTONE. This is one of the commonest of the fragmental rocks, and may be examined from many points of view. Thus we may regard it simply as a rock, and subject it to various physical tests in order to ascertain what is its specific gravity, its hardness, its power of resisting a crushing or a tensile strain applied in different directions, its solubility in different menstrua, such as cold and hot water, carbonated waters, spring waters, etc., its power of absorbing and retaining moisture in air or in vacua, its porousness to gases and water, and various other properties. We may analyze it for the purpose of determining of what substances it is composed, their relative proportions, and the influence which such circumstances may have had in originating the physical properties. We may regard it as a geological stratum, and search out the area over which it is spread; its varying thicknesses over such area, distinguishing those variations which were original from those which have been since formed by the partial removal of the rock; the proportion which it bears to other rocks of the same period; the modifications which occur in its physical and chemical composition according to locality, discriminating between such as were original and those which have arisen from subsequent alteration, and the causes which have brought about the alteration. We may examine it with a view to settling its approximate age by observing its position with respect to other strata, and the nature of its organic remains as compared with those found in other parts of the geological column. And we may regard it as revealing facts as to the past physical geography, such as the fluctuating height of the land, the direction of oceanic and fluviatile currents, the occurrence of rain, ripple marks, and many other matters.

A thorough comparative examination of sandstones necessarily involves an immense amount of research, and a systematic treatment of them would require a large volume. In this place, then, we can only refer to a few facts: no absolute definition can be given of a sandstone since its composition and structure is so various, and since it merges imperceptibly into many other kinds of rock, such as sand, conglomerate, grit, quartzite, shale, marls, clays, limestones, granite, gneiss, serpentine, and others. Cotta's definition is "small grains of some mineral, usually of quartz, cemented together by some mineral substance," which seems to embrace far too much, since he himself calls a rock, in which the grains are fragments of shell, and the cementing material carbonate of lime, a sandstone. If this is a sandstone so is granite and a host of other rocks to which the name would certainly be refused. Strictly, and hypercritically, speaking, it is difficult to say what is a small grain, so as to distinguish a sandstone from a quartz rock, or any of the aphanitic rocks, for these are composed of grains, which, however, require a microscope to be detected. And if it be said that the grains in these are crystalline, the difficulty is not removed, for many undoubted sandstones are more or less crystalline. If we modify the definition by replacing the phrase 'small grains' by 'grains visible to the eye,' the definition is still sufficiently vague and elastic. Dana's definition is also as wide, for he calls sand comminuted rock of any kind, and sandstone he terms agglutinated sand. Haughton's definition is more satisfactory. He calls all rocks composed of quartz, or of quartz plus something else, sandstones. This takes in quartzite, conglomerates, and breccias, which are excluded by Cotta. Haughton implies that the grains are visible, since he says a quartz rock differs from a sandstone in being so metamorphosed as to have become an uniform and compact whole. But he refers to some sandstones so fine grained that a lens is required to see the granules. Hence the question is suggested, how small may be the grain, and what amount of metamorphism may a sandstone have undergone without ceasing to be such? Haughton's definition excludes rocks in which granular opal takes the place of quartz.

Most, if not all, sandstones are metamorphic rocks; that is to say, all have undergone more or less change since their deposition. Some authors, however, restrict the term metamorphism to the great changes; but in such case we require to know what amount of change they consider to be embraced by the term. In what way has the alteration been effected? This is a question which has called forth much discussion; some persons consider the main agent to have been intense heat, others attribute most of the change to water; while others consider both water and heat to have been effective in producing the result. The circumstance that there is so much contrariety of opinion and dubiety, clearly manifests that little is known about the matter. It is difficult to write on the subject without being unduly biassed one way or the other; but, as it seems to us, aqueous solutions have effected the major part of the change, while heat, such as is conveyed by plutonic and volcanic rocks, have done far less. Heated rocks are of local development, both in time and space, and if they were the main agents we should expect the metamorphism to be most intense, and principally developed, in their neighbourhood. In the case of sandstones, it is rather the other way, for the alteration has been greatest, and is displayed more largely in areas distant from igneous rocks. Water, we know, is everywhere distributed in rocks, and water, or rather aqueous solutions, unquestionably have some alterative effect upon sandstones. In such case we ought to ascertain what such solutions can do, and then draw conclusions as to what change they may have done, and the support which the known facts give to the inference that they have done it. The same mode of inquiry should be applied to igneous rocks, and finally, the relative conclusions balanced for each particular case.

Among the most important changes which sandstones have undergone are crystallization, increased induration and cementation, and modification in the proportion and arrangement of the mineral constituents. It is unquestionable that quartz crystals have been formed from aqueous solutions, and there is little doubt that the sandstones which are composed to a greater or less extent of crystals have acquired such structure under the influence of the solutions which have percolated through them. The sandstones which possess this structure are not usually associated with eruptive rocks, and when they are, it is not clear that the heat of such rocks has had any share in the action. The Potsdam sandstone, the Vosgien sandstone, the quader-sandstone, some tertiary sandstones, some of the Cambrian and carboniferous grits are examples, and many others might be given. Induration and cementation frequently proceed together. Some of the simplest examples are afforded by the consolidation of sand into sandstones. Thus in the drift of Coddenham, Suffolk, is a band of hard blocks, which there is little reason to doubt have been formed from the sand itself by the action of carbonated waters holding lime, silica, and iron in solution. These blocks are used for building purposes, and many of them are as crystalline and as compact as some of the harder sandstones and grits of the palæozoic strata. It is probable that many of the 'grey wethers' and hard blocks in the sand of other districts have been formed in a similar way from materials *in situ*. In some parts of California are some curious cases of sandstones formed from sand *in situ*. Thus in Lone Tree Canon cretaceous shales have been fissured, and the fissures have been filled with sand which has since become so indurated and cemented that it resists denuding agents far better than the shale. The result is that it stands out in projecting walls, which have a strong resemblance to dykes. Instances abound to prove that quartz grains can be so softened by percolating solutions, that they indent one another by pressure, and that the silica is soluble. If the silica be taken up in one place and redeposited a little farther on, the crystalline appearance of sandstones would be a natural result. In the blocks of Suffolk, and in the grey wethers the cementing medium is chiefly silicate of lime and alumina; but in many sandstones silica only binds the particles together. Silication is one of the most common forms of metamorphism, and this we believe is intimately associated with the great abundance of quartz veins. Silication, cementation, crystallization, and induration, are frequently met with in sandstones at their junction with granite and other plutonic rocks; but there are many cases in which no appreciable amount of alteration can be assigned to the contiguity of such rocks, even when the sandstones have been lifted up by them. Those who hold that metamorphism is due to heat find this a difficulty, and evade it by suggesting that the granite or other plutonic rock has been erupted when cold. Thus, Professor Rogers, in describing the condition of the Potsdam sandstone in Pennsylvania, remarks that it is most metamorphosed near Willowgrove, where it still retains its bedded structure, although it has more resemblance to a quartzose felspathic gneiss than a fine-grained sandstone. It is decidedly crystalline, but the felspar is not so insulated from the quartz as in typical gneiss or granite. It appeared to him that it had undergone just that degree of semifusion requisite to develop an imperfect felspar, but insufficient to melt the siliceous sand diffused through the rock. He specially draws attention to the fact that it is in contact with very few trappean or granitic rocks of any kind, and observes, that like many other instances of metamorphism on a large scale, it seems rather to have been produced by general or diffused heat, most probably by the action of heated volcanic gases and vapour ascending through the joints and crevices of the rock. These remarks by Professor Rogers are the more significant if it be borne in mind that he attributes all metamorphism to heat, and, so far as we can gather, he never admits the efficient action of water.

A cross reference has been made from FREESTONE, E. C., to this article, so that we would just mention that those sandstones which can be worked as easily in one direction as in another, are called freestones; but this term is also applied to other rocks which present the same homogeneousness of texture.

SARCODE. A term applied by Dujardin to designate the soft parts of the *Amœba*, *Actinophrys*, *Foraminifera*, *Infusoria*, and other animals in which we can with difficulty trace the simplest rudiments of organs. Since his time it has been ascertained that this sarcode is much more nearly allied to the mucous membrane of the vertebrated animals than to the flesh [SPONGIADÆ, E. C. S.], and that amongst the lower classes of animals it possesses sufficient differences in physical and chemical properties to warrant the belief that at least two, probably several, distinct substances have been confounded together. This seems to have been recognized by Dr. Bowerbank and Mr. Carter. Dr. Bowerbank has proposed to call the firmer portion of *Amœba*, the *ectosarc*, and the less consistent the *endosarc*, and has pointed out their difference of behaviour when subjected to chemical reagents. [AMŒBA, E. C. S.] Mr. Carter makes a similar division, but employs different names; thus his *diaphane* answers to the ectosarc, and his *sarcode* to the endosarc. The hardened surface of the ectosarc he calls *pellicula*.

According to Dr. Bowerbank, sarcode, or a substance identical with it, although passing under another name, is present in all the members of the animal kingdom from the highest to the lowest. The same characters are presented by it as by the mucous membrane lining the intestines of the sea-anemones, the starfishes, and the mouse. "Thus, if we trace this substance upward from *Actinophrys Sol* to man, through the *Spongiadæ*, and all the other gradations of animal existence, it is always found to be present and always intimately connected with the digestive process. Especial organs for respiration, nerves for sensation, muscles for motion,—all these may apparently be dispensed with in turn, and yet the animal will perform its accustomed functions; but this substance, as mucous lining of intestine or sarcode, as I have before observed, appears never to be absent. It even seems to acquire a greater importance in the animal economy as we descend in the scale of beings, until the animal in *Amœba* and *Actinophrys* becomes entirely composed of it. . . It thus appears to be the most constant and perhaps the most important attribute of animal life. In its most isolated form, it apparently supersedes every other organ in the animal. In *Amœba* it appears to exist in its simplest and most isolated condition; it moves by its contractile power and absorbs nutriment. In *Actinophrys* it adds another function to its list of capabilities, that of throwing out pseudo-tentaculæ, by which it entangles and conveys its prey to its surface. In the foraminated animals it develops further powers: it secretes a chambered shell for the protection of its surface, and throws out pseudopodia by which it moves over comparatively a considerable space in a short period, and anchors itself at its pleasure in any position or locality it may choose to remain in. As we proceed higher in the scale of creation, its functions become more limited, but in the act of digestion it always appears to take a most important part." (Bowerbank, *Monograph of the British Spongiadæ*, vol. i. 1864.)

SCELIDOSAURUS, a genus of Dinosaurian reptiles. Under HADROSAURUS, E. C. S., a notice is given of a strange form which is conjectured to have been a land-frequenting, browsing, and jumping reptile, having many remarkable peculiarities of structure. Under the present heading will be noticed a form of an analogous kind, which like *Hadrosaurus*, had, in all probability, a more specialized organization than the crocodiles or any reptiles of the present day. This is a noteworthy fact, for *Scelidosaurus* is a very antique reptile, far older than the *Hadrosaurus* of America or the *Iguanodon* of England, its remains having been found in the lower lias of Dorsetshire, and in the Rhætic beds of the west of England. The femur of *Scelidosaurus Harrisonii* had a deeply cleft proximal end; rough surfaces, tuberosities, and ridges on the shaft more marked than in most of the cretaceous dinosaurs; and a compact thick wall to the medullary cavity; characters which indicate an extraordinarily high development of the muscular force in the hind limbs of this creature. The tibia and fibula also have ridges for the attachment of muscles. These various bones indicate a leg of more slender proportions than that of *Iguanodon* and its contemporary allies. From what we know of the more recent dinosaurs, and from what has been discovered respecting *Scelidosaurus*, it seems highly probable that *S. Harrisonii* habitually frequented the land; and the enormous development of the hind legs evidently had a relation to their vigorous employment. Did it jump or walk on its hind legs? Facts lend some support to the views that it did either one or the other, and that such a mode of progression was a usual feature amongst the oldest terrestrial reptiles of highest development. If such views were confirmed it would be requisite to reconsider the evidence upon which the footprints on the sandstones of Connecticut have been supposed to be avian, since *Scelidosaurus* was capable of making footprints of a very similar character, and this genus, be it remarked, is nearly, if not quite, as old as the footprints. Although evidently adapted for terrestrial life, *S. Harrisonii* seems to have frequented the sea occasionally. This is apparently shown by the occurrence in the lias clay of the various bones forming the knee joint in their true relative positions. When the leg was buried the ligaments had not been sufficiently decomposed to allow of the displacement of the bones. In the same clay the bones of a young individual were discovered. The most important specimen known of this genus is the nearly complete skull from the lower lias near Charmouth, which is fully described by Professor Owen. In some features it approaches nearest the crocodile, in others to *Hylæosaurus*, and in others to the lizard. The dentition resembles the iguanodon type, but Professor Owen is undecided whether it was correlated with herbivorous or carnivorous habits. The facts of the case are these: "The teeth are small, or of lacertian proportions to the jaws; they are numerous and close set, implanted in sockets forming an uninterrupted series along the alveolar border. The fang is simple, and longer than the crown, presenting a full ellipse in transverse section, and projecting a little beyond the socket. In the upper jaw the crown begins by bulging outward, with a smooth convexity, subsiding as it gradually expands, and dividing to be continued along the middle and the margin, with intervening concavities, producing an undulated surface across the broadest part of the crown. The marginal convexities or ridges terminate each in a point at the broadest part of the crown; whence the plate-shaped tooth, having thinned off to an edge, this is divided on each side into five or six small points; these denticulate margins converge straight, at an angle rather less than a right one, to the apex of the tooth, which is formed by the pointed termination of the median convexity. The crown is coated by a polished enamel, of jet blackness in the fossil, smooth under the lens upon the convexities, finely punctate in the hollows of the expanded part of the crown. The whole tooth in the upper jaw is very slightly bent backward with as slight an oblique twist, making the hinder angle overlap the front angle of the crown of the tooth behind. The inner surface of four of the hind teeth of the right ramus of the jaw shows a crown with a large proportion of the serrated part, and with the borders less equal, the anterior one showing as many as nine points, and the expanded coronal surface is uniformly and gently convex. On the left side, in an extent of the alveolar border of the upper jaw measuring 4 inches, there are 19 sockets, and only one tooth missing. On the right side, in an extent of 3½ inches, there are 16 sockets, and 3 teeth missing. The fractured part of the jaw yields evidence of the usual reptilian provision for successional teeth in reserve alveoli, containing tooth germs, at the inner side of the base of the teeth in place. The teeth gradually increase in size from the hindmost to the fifth in advance, and then gradually decrease in size to the fractured forepart of the jaw. Were the serrated borders of the terminal half of the crown to be worn down, the teeth of the *Scelidosaurus* would be like those referred to *Hylæosaurus* in my monograph of 1856. There is no evidence, however, that any of them have been so worn down; in this respect they resemble more the teeth of *Echinodon*, the upper teeth in *Scelidosaurus* differing chiefly in the proportions of length to breadth of the crown. Whether the anterior teeth had the simple laniariform character at the forepart of the jaws in *Scelidosaurus*, as in *Echinodon*, remains to be proved. The finely and sharply serrated and pointed teeth of the *Scelidosaurus* glided upon each other, the upper on the outer side of the under, like the blade-shaped crowns of the carnassials of feline mammals; and yet the similarity of the teeth, in their number and uniformly small size, to those of the modern iguanas, suggests that they may have been put to like uses. The compressed serrate crowns in those herbivorous lizards worked obliquely upon each other, in a similar scissor-blade way. In *Iguanodon* the dentition is obviously modified more decidedly for mastication of vegetable substances. In *Scelidosaurus* it is adapted for division of such substances, but it would be equally effective in piercing and cutting or tearing through animal textures. If this dinosaur occasionally went to sea in quest of food, it may be expected to present in the forepart of the jaws, wanting in the present specimen, laniariform teeth, as in *Echinodon*, for the prehension and retention of living prey. Should these prove to be absent, and the dental series to begin as it ends, it will incline the balance of probability to the phytophagous nature of the liassic *Scelidosaurus*."

(Owen, *British Fossil Reptilia from the Oolitic Formations; Palæontographical Society's Monographs.*)

SCHORLOMITE is a dark bluish or black mineral, having a vitreous lustre and a conchoidal fracture, characters which give it a resemblance to schorl, whence its name. The specific gravity of the various specimens observed has ranged from 3·74 to 3·86, and the hardness is about 7. The chemical composition has been ascertained by several chemists, but that which approaches most closely to that of the mineral in a theoretically pure condition is Whitney's, as given below. The specimens were brought from Arkansas.

Silica	25·66
Titanic acid	22·10
Ferric oxide	21·58
Lime	29·78

It is associated with elæolite and brookite in the Ozark Mountains, Arkansas, and is also found at Kaiserstuhl. A mineral which differs little from schorlomite has been discovered at Ivaara, Finland, and has been described by Nordenskiold under the name Ivaarite. It is somewhat lighter than schorlomite, and the proportion of silica is rather less.

(Dana, *A System of Mineralogy*, 5th ed.)

SCOLYMUS, a genus of plants belonging to the *Cichoraceæ*, and the only one of that group which possesses a resemblance to thistles. The leaves have spiny points, and the flowers are of a rich saffron colour. The species inhabit the countries surrounding the Mediterranean sea.

SCOMBRIDÆ [E. C. vol. iv. cols. 725, 726]. As formerly understood and defined, this family comprised a great number of genera and species which presented amongst themselves much variety of form and structure. Of late years it has been considered best to divide the old family into several smaller families. Amongst the most recent definitions of the restricted group is that given by Dr. Günther, which is thus worded by him :—" Body generally elongate, compressed, naked, or covered with scales of small or moderate size; eye lateral. Dentition variable. The infraorbital bones do not articulate with the præoperculum. The spinous dorsal less developed than the soft, or than the anal, either continuous with or separate from the soft portion, sometimes entirely absent. The soft dorsal and the anal sometimes divided posteriorly into finlets. Ventral thoracic (jugular in *Pteraclis* and *Hypsiptera*), sometimes rudimentary, or entirely absent. No prominent papilli near the vent. Gill opening wide, generally seven branchiostegals, pseudobranchiæ (absent in *Coryphæna*), and an air-bladder (absent in *Elacate*, *Echeneis*, *Stromateus*, and *Coryphæna*); pyloric appendages generally in great number. Vertebræ, $\frac{(10)\ 10 + x}{14 + y}$."

He subdivides the family into five minor groups, named respectively *Scombrina*, *Nomeina*, *Cyttina*, *Stromateina*, and *Coryphænina*. The first group comprises nine genera, viz., *Scomber*, *Thynnus*, *Pelamys*, *Auxis*, *Cybium*, *Naucrates*, *Elacate*, *Echeneis*, *Hypsiptera*. The second group, *Nomeina*, embraces the six genera, *Gasterochisma*, *Nomeus*, *Cubiceps*, *Neptomenus*, *Platystethus*, *Ditrema*. *Cyttina* comprises the genera *Zeus*, *Cyttus*, and *Oreosoma*. *Stromateina* includes *Stromateus* and *Centrolophus*. *Coryphænina* is formed by the genera *Coryphæna*, *Brama*, *Taractes*, *Pteraclis*, *Schedophilus*, *Diana*, *Ausonia*, *Mene*, and *Lampris*.

The mackerel family has representatives in almost every sea, and a fair proportion of the species are met with on the British coasts. In the sequel we shall mainly confine our remarks to the British species. The best known and the most useful to man as an article of food is the common mackerel. It is a remarkably active and powerful swimmer. It ranges over a wide oceanic area, frequenting both sides of the North Atlantic in the middle latitudes. On the European side the most southern point is the Canary islands. It is constantly moving about from place to place, but at particular seasons of the year the shoals migrate from the deeper to the shallow water for the purposes of reproduction and deposition of ova. On the west coast of England the movement on shore commences early in the year, sometimes in February; but the general movement does not usually take place before March. Frequently the first comers are for the most part males. The weather has little or no influence in regulating the time of these periodical movements, but it does cause the fish to swim higher or lower in the water. From this latter circumstance not having been taken into account, it has doubtless frequently happened that shoals have passed a portion of the coast line without having been perceived. There is no foundation for the supposition that the mackerel issue in great swarms from the north and invade the shores of the south. They are generally distributed, and their journeys are only local. In accordance with this, it is found that the individuals vary slightly according to locality. In the Baltic and off Sweden the species is not common, and the individuals are usually small. In some parts of the Mediterranean the individuals are small and dry; while at Nice they are far superior in size and flavour. The British mackerel, more especially that of the west coast, is believed to excel all others.

Scomber colias. Like the common mackerel, this species ranges from the Mediterranean, and along both the European and American shores of the Atlantic. It is, however, rare on the south coasts of Britain, and seems to be less frequently met with on them now than formerly. Within the memory of some old fishermen specimens were not unfrequent, but for some years past they have become rare.

Scomber punctatus. This is a third, and very rare species. Only one specimen seems to have been obtained; it was caught in a sean, at Looe, in Cornwall, July, 1848.

S. scriptus is a species described by Mr. Couch, of which a few individuals only have been caught off the Cornish coast.

Besides the above, there are about ten exotic species. *S. pneumatophorus* seems to carry on the distribution of the genus from the southern borders of the range of the common mackerel. It occurs in the Mediterranean, and on both sides of the Atlantic. It ranges as far south as the Cape of Good Hope. One species lives in the Red Sea; a few in the seas bounding the south coasts of Asia as far east as China; and one is common to the seas of Amboyna and Australia.

Thynnus pelamys. The Bonito, which chiefly abounds in the warmer parts of the Atlantic and Indian oceans, occasionally wanders to the British Isles. Specimens have been captured off Scotland, Ireland, and west coast of England.

T. alalonga. The long-finned tunny, or Germon, as Mr. Couch calls it, is another species which, chiefly frequenting more southern seas, appears occasionally on British shores. Mr. Couch records three examples: two were taken in Mount's Bay, Cornwall, and the third off Portland. The other species of *Thynnus* are exotic, but have a similar range to *Scomber*, although probably not quite so extensive. They frequent the Atlantic, and the oceans off the south coast of Asia.

Pelamys Sarda. This is a very powerful swimmer, and possesses active predatory habits. It occurs in the Mediterranean, on both sides of the Atlantic, and ranges as far south as the Cape of Good Hope. Its occurrence so far north as Britain has been rarely recorded, but one individual has been taken as far north as Montrose. It is remarkable for its high animal heat, which sometimes exceeds that of the water by 10° or 12° The exotic species dwell in the Red Sea, the Mediterranean, and the Sea of Japan. One species is found in the Pacific.

The only other British species of this family not mentioned in the E. C. is *Centrolophus Britannicus*, which was first found off Cornwall in February, 1859.

The range of the family is nearly the same as that of the principal genus, *Scomber*, that is, from the North Atlantic on the north-west to Australia on the south-east. Only two or three species range into the Pacific Ocean, as, for instance, *Thynnus pacificus*, *Pelamys chilensis*, and *Echeneis lineata*.

(Günther, *Catalogue of the Acanthopterygian Fishes in the British Museum Collection*, vol. ii.; Couch, *A History of the Fishes of the British Isles*, vol. ii.)

SIGILLARIA [E. C., vol. iv. col. 766]. Comparatively little positive knowledge has been acquired of late years respecting this genus, so that palæophytologists cannot confidentially assert what its minute structure, general appearance, and affinities are. The natural consequence is that one cannot rely on the species assigned to the genus really belonging to it, nor that the current propositions for referring certain fragmentary parts, such as leaves, seeds or spore cases, roots, &c., are trustworthy. Hence we ought to regard the species of *Sigillaria*, and various genera supposed to be connected with it, as provisional terms. There is no question that *Stigmaria* is founded upon the roots of *Sigillaria*, since the connection between the two forms has been seen and described by Messrs. Binney, Dawson, and several other observers. In *Stigmaria* there is a central vascular column surrounded by a cylinder of scalariform vessels, the whole being enveloped in a thick layer having some resemblance to bark. The outer surface of the cortical layer is marked with numerous pits from which long cellular rootlets proceeded. According to Carruthers, no medullary rays are developed in the central axis. According to Brongniart, whose description of the stem structure of *Sigillaria* is the best, there is a central cellular axis, a surrounding vascular cylinder, and an investing thick cellular cortical layer; he also states that the vascular cylinder is traversed by medullary rays. This last observation is said to be erroneous by Carruthers, who endeavours to show that Brongniart mistook a series of cracks for medullary rays. Dawson also is of opinion that medullary rays exist. The presence or absence of these rays is of importance in assisting us to determine the affinities of the genus. Dawson regards it as belonging to the gymnospermous phænogams, while Carruthers ranks it amongst the cryptogams along with *Lepidodendron*.

It is curious to notice the bias which the above views have given to the conclusions of the observers last named respecting the relationship of the fruits found in the coal measures. Dawson admits that he has never found any reproductive organs attached to a *Sigillaria;* but he observes that *Sigillaria* is the most abundant plant in the carboniferous period, while the fruits named *Trigonocarpum* and *Rhabdocarpus* are also various in structure, and exceedingly abundant. The structure of the fruits indicates a phænogamous plant. The only plants which answer the conditions are conifers, *Sigillaria*, and *Calamodendron*. The first are not abundant enough; and the last genus is very closely allied to *Sigillaria*. If then, he adds, these fruits were not produced by *Sigillaria* they were formed by species which were very abundant in the living condition, but very rare as fossils.

Mr. Carruthers arrives at a different conclusion; but neither he nor, so far as we know, any one else has ever seen the attached reproductive organs of *Sigillaria*. It has been observed that some beds are almost wholly composed of *Sigillaria, Stigmaria*, and cones containing spores; and that similar cones are exceedingly numerous in all *Sigillaria*-containing strata. The inference is that in all probability the abundant cryptogamous trunks and roots are intimately connected with the abundant cryptogamous spore cases. These spore cases have been placed in such genera as *Flemingites*. They are unquestionably cryptogamous organs of fructification, and have some resemblance to those borne by the *Lycopodium* of the present day. The abundance of these bodies is something almost inconceivable. Many coals, more especially those which are most bituminous, are largely composed of them; indeed, some cases are shown in which beds from a few inches to several feet in thickness are entirely formed of sporangia. These spore cases appear in the coal as little minute coins, sometimes having their edges exposed, and sometimes lying flat so as to look like discs. These discs had long been observed in coal, but it was not until about thirty years ago that their true nature was known, when Professor Morris described them as the spore cases of cryptogams. This fact seems to have been forgotten until a short time since a large fragment of a cone was found in which the sporangia retained the natural position. Then it began to dawn upon the mind that when these coal-beds were forming, the land was covered with vast forests of cryptogamous trees, which during the fruiting season were loaded with cones, each of which was made up of hundreds of leaves, each leaf supported from 30 to 50 spore cases, and each spore case was filled with a *Lycopodium*-like powder formed of thousands of spores. Such is the multitude of the sporangia that probably they were discharged in immense showers, like those formed when the vast pine forests of Scotland and Norway shed their pollen.

The evidence is indecisive, so that until more positive testimony is forthcoming, some botanists will maintain *Sigillaria* to be cryptogamous and others dicotyledonous. Dawson recognizes considerable differences amongst the *Sigillariæ*, and proposes to divide the 21 Nova Scotian species into 6 provisional genera, which he names, *Favularia*, Sternberg; *Rhytidolepis*, Sternberg; *Sigillaria*, Brongniart; *Clathraria*, Brongniart; *Leioderma*, Goldenberg; and *Syringodendron*, Sternberg.

(Dawson, *Q. J. Geol. Soc.* xxii. p. 95 *et seq.*; Carruthers, *Q. J. Geol. Soc.* xxv. pp. 248—254; Huxley, *Scentific Opinion*, iii. pp. 4—6; Carruthers, *Geol. Mag.* ii. p. 433; vi. p. 299.)

SILICA, a compound of oxygen and silicon in the proportion of 53·3 per cent. by weight of the former, and of 46·7 per cent. by weight of the latter element. This statement is admitted to be correct by all chemists, whatever may be their views as to the chemical formula which ought to be assigned to this substance; and, so far as weight is concerned, it agrees with the proportion given in Silica, E. C., vol. iv. col. 768, where, however, 20 is a misprint for 21; but it differs from that given under Quartz, E. C., vol. iv. col. 516, which is wrong. The element silicon has not yet been found in the native state, but several modifications of it are known, each of which has its own distinctive properties, or, rather, distinctive intensities of properties. The account given under Silica, E. C., vol. iv. col. 767, is scarcely correct, since it will not apply to all the modifications of silicon, and since all the statements are not applicable to any one modification. A second account is given under Silica, E. C., A. and Sci. Div., vol. viii. col. 567, and as this is not only correct, but supplies what is wanting in that just referred to, we quote it here. "Silicon, like carbon and boron, exists in three modifications. As above prepared it is a dull brown powder; is soluble in, and heavier than, water; is a non-conductor of electricity; is soluble in hydrofluoric acid, and in a warm solution of potash; burns readily and brilliantly when heated in the air, and is, moreover, *amorphous* (Si γ). If the amorphous silicon be strongly heated, it becomes semi-crystalline, or *graphitoidal* (Si β); is denser and darker in colour, does not burn in oxygen, is not soluble in hydrofluoric acid, and is a conductor of electricity. *Crystalline* silicon (Si α) occurs in the form of six-sided prisms or pyramids, whenever the process for its preparation has included the application of the most intense heat of a wind furnace." The reader will notice the gradation in properties according to the density of the varieties, in which respect there is much analogy between silicon and carbon. The passage quoted gives the idea that the density is increased by the application of heat only; but it is probable that, as in the case of carbon, the increase in density is really due to increase in pressure, and that heat is simply the means by which the pressure is applied. For further remarks bearing upon this point, see Carbon, E. C. S.

In Silica, E. C., the compound so named is said to consist of 3 parts of oxygen and 1 of silicon; this corresponds to the formula SiO_3, which has been long adopted by most chemists; but of late years the formula SiO_2 has been extensively employed. The difference depends, not upon the quantity of silicon and oxygen contained in silica, but upon the value which should be assigned to the combining proportions of these two elements relatively to all the others. In the formula SiO_3 the smallest combining proportion of silicon is supposed to be 21, and of oxygen 8, that of hydrogen being 1; but in the formula SiO_2, the combining proportion of silicon is valued at 28, and of oxygen 16, that of hydrogen still remaining unity. In SiO_3 the relative weights of the two elements are as 21 to 24; and in SiO_2 they are as 28 to 32. The proportion is the same, but the values of the terms are different. There are many reasons why 28 is preferable to 21 as the atomic weight of silicon; but as this subject belongs to pure chemistry, it would be out of place to discuss it here.

Silica is as important an element in the inorganic world as carbon is in the organic. Silica appears to be the active mineralising agent in all the depths of the earth, while carbonic acid is most active at and near the surface. Silica is most stable and inert when in its densest condition, acquiring activity only when it has been somewhat rarified, as by the action of heat or water. Carbonic acid, on the other hand, is inert when in its normally most expanded state, becoming active only when it has been condensed by solution in water. The two acids are in many respects the antitheses of each other, inasmuch as the same agent frequently produces opposite effects upon them. Thus, for instance, the application of heat weakens the chemical affinity of carbonic acid, and it is generally easily separated from its compounds by this means; while the same increase of heat tends rather to strengthen the chemical affinity of silicic acid.

Silica is common almost everywhere, and is the most abundant of known compounds. It enters into the composition of all but one of the groups of rocks, the exception being the limestone group; but even in this it frequently occurs in considerable quantities as an accessory ingredient. On the average, it may be estimated that silica forms one-half the weight of all the rocks known, and it is probable it forms a still larger proportion of the unknown ones which lie beneath them. Some rocks consist of nothing but silica, such as the quartzites, the purer sandstones, and some sands; others contain about 75 per cent., such as granite, gneiss, and other deeply-seated rocks; others about 65 per cent., such as mica and other schists, which generally overlie granite, and the older igneous or volcanic rocks, such as some of the porphyries, traps, &c.; others, again, contain about 50 per cent., such as the more recent volcanic rocks. So generally present is it, that several of the classifications of rocks are based upon their basic or acidic character, the basic including those which are poor in silica, but rich in bases, while the acidic includes those which are poor in bases but rich in silica. The question why some rocks are acidic and others basic is one which has called forth a large amount of discussion, but lithologists are far from being agreed as to what is the correct answer, although it is one of the most important questions which has yet been suggested by lithological inquirers. It is one which cannot be considered here, but as the nature of the answer largely depends upon the extent of our knowledge of the history, properties, and changes of silica, a passing allusion to it must suffice.

There are several varieties of native silica, which differ in their physical properties; but the most common are those which present the highest degree of hardness, insolubility, infusibility, and stability, and in these respects they exceed most minerals. Hence it happens that when a group of rocks are exposed under somewhat similar conditions to the same natural destructive or rather disintegrating agents, the more highly silicated rocks are the least affected. Thus, where extensive denudation has occurred, the hills and mountains are formed of a more highly silicated material than that which constitutes the bottoms of the valleys. Again, sands, shingles, and all the other accumulations of matter which has undergone the largest amount of transport and grinding, are almost exclusively of a highly siliceous nature. Siliceous deposits are most abundant along those shore lines where the waves are most violent; and they are also more abundant in the elevations than in the depressions. These facts are intimately connected with another, viz., that in the majority of cases in which mountain masses are composed of unquestionably sedimentary strata, the geologist discovers that they occupy the area upon which the coast lines of the older periods of the world were most persistent. Examples of this are afforded by the Welsh mountains in Great Britain, and the Appalachian range in North America. Possibly the same kind of generalization will apply to the mountains formed of granite and other highly silicated rocks, in which stratification is scarcely, if at all, perceptible, when we know more about them; and it is also possible that the least highly silicated rocks which were formed in the earliest geological periods now occupy the lowest positions, that is, lower than most of the rocks of contemporaneous formation. In short, it may be accepted as a general rule, subject to exceptions due to modifying circumstances which cannot be particularized here, that the most silicated sedimentary rocks usually occupy higher positions than such as contain little or no silica; and that the most mountainous parts of a given area generally mark the positions where the largest quantity or greatest thickness of hard silica and silicates have been accumulated. If there had been but one kind of silica having the properties of quartz, this rule would not be applicable, since a quartzose or highly silicated rock when once reduced to the fragmental condition would have lost its resisting qualities as a mass, and would have rarely, if ever, regained them, supposing all other conditions to have remained unaltered. There is, however, a second kind of silica, through the intervention of which the sands and fragmental deposits are rendered hard and durable. We propose, then, to consider here some of the properties of the two kinds of silica, and to refer to SANDSTONE, E. C. S., for an account of the usual way in which friable rocks are made tough.

Mineralogists have long recognized that there are two kinds of silica, but they failed to recognize the marked character of their distinctness, and the important consequences which result therefrom. They were known as the soluble and insoluble modifications; the first having a sp. gr. of 2·2, and the second a sp. gr. of 2·6. They present the same relation between density and alterability as occurs in the element silicon. The difference in properties appears to be due partly to some agent that modifies the intensity of the attraction of molecule for molecule, or, as it is called by Graham, *idio-attraction*; and partly upon some alteration of the molecular forces whereby the silica is rendered at one time crystalline, and at another colloidal or gum-like in its nature. In order to prevent confusion, the one variety will be called silica, insoluble silica, crystallized or crystallizable silica; and the other metasilica, soluble silica, colloidal or gelatinous silica, amorphous silica; while silicic acid will be used as a general term applicable to both.

The idio-attraction of a colloid such as metasilica, appears to be somewhat different in character from that of a crystalloid such as silica, since in the former case simple cohesive attraction takes place between the molecules, while in the latter there is the same kind of attraction acting with greater intensity and a certain orderly mode of arrangement. It would appear that there are certain conditions which favour the action of the regulating or crystallizing force, and that when they are absent or counteracted the substance assumes the amorphous or colloidal state. Metasilica is capable of taking up almost any amount of water, and its solubility depends, in a great measure, upon its degree of hydration. Thus a jelly which contains 1 per cent. of metasilica and 99 per cent. of water is, according to Graham, soluble in 5000 parts of water; if it contains 5 per cent. of metasilica it will dissolve in 10,000 parts of water; if it is less hydrated it is less soluble; and if it is rendered anhydrous it appears to be absolutely insoluble, "like the light, dusty silicic acid obtained by drying a jelly charged with salts, as in the ordinary analysis of a silicate." The same author further remarks that "the liquidity of silicic acid is only affected by a change which is permanent (namely, coagulation or pectization), and by which the acid is converted into the gelatinous or pectous form, and loses its miscibility with water. The liquidity is permanent in proportion to the degree of dilution of the silicic acid, and appears to be favoured by a low temperature. It is opposed, on the contrary, by concentration and by elevation in temperature. A liquid silicic acid of 10 or 12 per cent. pectizes spontaneously in a few hours at the ordinary temperature, and immediately when heated. A liquid of 5 per cent. may be preserved five or six days; a liquid of 2 per cent. for two or three months; and a liquid of 1 per cent. has not pectized after two years. Dilute solutions of ·1 per cent. or less are no doubt practically unalterable by time, and hence the possibility of the soluble silicic acid existing in nature. No solution, weak or strong, of silicic acid in water has shown any disposition to deposit crystals, but always appears on drying as a glossy colloidal hyalite. The formation of quartz crystals at a low temperature, of so frequent occurrence in nature, is still a mystery. I can only imagine that such crystals are formed at an inconceivably slow rate, and from solutions of silicic acid, which are extremely dilute. Dilution no doubt weakens the colloidal character of substances, and may therefore allow their crystallizing tendency to gain ground and develop itself, particularly where the crystal once formed is completely insoluble, as in quartz." It is particularly noticeable that silica may be concentrated in water to a high degree without assuming the solid state when placed under certain conditions. Thus when a colloid such as metasilica is dissolved in a fluid crystalloid such as water, and the solution is placed on a colloidal membrane resting on water, the water on the membrane slowly passes through it to join the larger mass beneath, and leaves the metasilica behind. The solution is thus rendered stronger, and gradually passes from perfect liquidity to a fluid having the consistency of a thick oil. When the concentration is carried beyond this stage, the metasilica separates in the gelatinous form or pectizes. By continuing the process more water is separated, and the jelly divided into a hard and a fluid part, which Graham calls clot and serum. When all the water has disappeared, the silicic acid remains as a hard, stony, vitreous mass.

These strong solutions differ from ordinary solutions inasmuch as the particles of the solid dissolved are separated from the solvent by apparently trivial causes. Indeed, it may be noticed that Professor Graham avoids the word "solution," and adopts that of "liquid." But neither of them is strictly applicable to these peculiarly constituted fluids. They evidently require a new name. But in this article we have retained the old one, as the reader may judge from the context what is the meaning to be attached to them. A liquid silicic acid containing 5 per cent. of the acid is gelatinized in about an hour by contact with pounded graphite. The change is due to some physical modification, since the graphite is chemically inactive. A 2 per cent. silicic acid is gelatinized by the same means in two days. Many powders have the same effect; as also many alkaline salts. The alkalies, on the other hand, act powerfully in liquefying the silicic acid; that is, in reducing it to the condition in which it was when in a solution of the ordinary character. Thus, according to Professor Graham, 1 part of caustic soda, dissolved in 10,000 parts of water, will liquefy 200 parts of metasilica (estimated dry) in 60 minutes, at 100° C. "The alkali, too, after liquefying the gelatinous colloid, may be separated again from it by diffusion into water upon a dialyzer. The solution of these colloids in these circumstances may be looked upon as analogous to the solution of insoluble organic colloids witnessed in animal digestion, with the difference, that the solvent fluid here is alkaline, not acid. Liquid silicic acid may be represented as the peptone of gelatinous silicic acid; and the liquefaction of the latter by a trace of alkali may be spoken of as the peptization of the jelly." As a certain class of writers have attributed much importance to high temperatures in the formation of siliceous minerals, the behaviour of silica under such circumstances must not be overlooked. Silica fuses at about 2,000° C., or an intensity of heat far above that required to fuse iron; but when fused, and then allowed to cool, it retains a gelatinous consistency in which it is capable of being drawn into threads until far below its fusing point, or at a low red heat. This remarkable property is possessed by many other substances, and is termed *surfusion* or superfusion by Fournet, who considers it to be a full explanation of the known facts which indicate the plasticity of native silica. The molecular condition of silica which has been reduced to the gelatinous state by means of heat, appears to be undistinguishable from that possessed by it when gelatinized by other means. On this branch of our subject, however, there is room for much further inquiry.

Silicic acid, then, varies in its nature according to the conditions by which it is surrounded; and it remains for future inquirers to ascertain more precisely what those conditions are, in order that we may gain a more thorough knowledge of the nature of this compound than we now possess. The denser form, or silica, occurs native, as quartz and its varieties; while the lighter form or metasilica, is not known in the native state, as it always occurs in combination either with water, as in opal, or a base, as in the metasilicates. For further particulars respecting silicic acid in its native state, see QUARTZ, E. C. S. There is, however, one group of compounds which require mention here, on account of the interest which may attach to them from a physiological point of view. Silicic acid combines with water to form hydrates. By appropriate means, a portion of this water may be replaced by a corresponding proportion of glycerine, alcohol, and other oxy-hydro-carbons, and each of these products may occur either in the perfectly dissolved state, or in the intermediate viscous fluid form, or as a jelly. Professor Graham proposes to call the liquid and gelatinous hydrates of silicic acid *hydrosol* and *hydrogel*. The corresponding alcoholic compounds he calls *alcosol* and *alcogel* of silicic acid; and *etherosol*, *etherogel*, *glycerosol*, *glycerogel*, &c., of silicic acid, indicate the compounds in which ether, glycerine, &c., occupy the place of the water in the hydrate. He then makes the following observations on this group of compounds. Their production implies a wider range of affinity than could well be indicated. The organic colloids are no doubt invested with similar powers of combination, which may become of interest to the physiologist. The capability of a mass of gelatinous silicic acid to assume alcohol, or even oleine, in the place of water of combination, without alteration or disintegration of form, may perhaps afford a clue to the penetration of the albuminised matter of membrane by fatty and other insoluble bodies, which seems to occur in the digestion of food. Still more remarkable and suggestive are the fluid compounds of silica. The fluid alcohol compound favours the possibility of the existence of a compound of the colloid albumen with oleine, soluble also, and capable of circulating with the blood. The feebleness of the force which holds together two substances belonging to different physical classes—one being a colloid, and the other a crystalloid—is a subject deserving notice. When such a compound is placed in a fluid, the superior or diffusive energy of the crystalloid may cause its separation from the colloid. Thus, in hydrated silicic acid, the combined water (a crystalloid) leaves the acid (a colloid) to diffuse into alcohol; and if the alcohol be repeatedly changed, the whole of the water may be removed, alcohol (another crystalloid) taking its place. The liquid in excess, or the alcohol in the present case, gains entire possession of the silicic acid. The process is reversed if alcohol be placed in a considerable volume of water. Such changes illustrate the predominating influence of mass. Even the compounds of silicic acid with alkalies yield to the decomposing force of diffusion. The compound of silicic acid with one or two per cent of soda, is a colloidal solution, and when placed in a dialyzer over water in vacuo, to exclude carbonic acid, suffers gradual decomposition. The soda diffuses off slowly in the caustic state.

Many writers express surprise that silica should have an extremely weak acid character, and yet form remarkably stable compounds. The anomaly would probably lose much of its force if the conditions under which the acid acts were more fully taken into account. For example, take the cases of carbonic and sulphuric acids. Under ordinary conditions carbonic acid is a gas, so that when it forms a solid carbonate its solidity is due to its chemical affinity, or attractive force, towards the substance it combines with. When any circumstance is brought to bear upon the carbonate which would diminish the intensity of the attractive force between the carbonic acid and base, it renders the acid more easily converted into the gaseous form. As is well known, it does not require much to do this; so that by raising the temperature to a moderately high degree, all carbonates are decomposed. The same remark applies to sulphates; but as sulphuric acid is a liquid under ordinary conditions there is more difficulty in rendering the sulphuric acid sufficiently rare to destroy its chemical affinity. Silica in its ordinary state is a solid, so that in its case a far greater amount of heat would be required to reduce its density to so low a degree as shall overcome its chemical affinity. Thus a degree of heat which would render silica fluid, and best adapted for entering into chemical combination, would render carbonic and sulphuric acids too rare. It evidently depends upon conditions, whether we call a given acid weak or strong. Every acid is weak under one set of conditions, and strong under another; but it conveys a false impression to call one acid weak and another strong because the conditions happen to be favourable for the one and unfavourable for the other. As has already been noticed, it should be remembered that carbonic acid is a gaseous substance and silicic acid a solid one; that they are at opposite ends of the scale with respect to heat; and that carbonic acid requires to be condensed before it will combine at the ordinary temperature, while silica requires to be rarefied. This consideration seems partially to explain the comparative fixity of native silicates. That silicic acid does not combine with much intensity of action is probably due to its slight solubility in water, whereby it is only enabled to act slowly, and upon small quantities of base. If a comparison could be made between similar masses of silicic and carbonic acids, having the same degree of concentration, it appears doubtful whether silicic acid could then be called weak in contrast with carbonic acid. There is probably a third form of silica, but as yet little is known about it. Like opal, it has a low density, the specific gravity being 2·2—2·3; and, like quartz, it crystallizes in the rhombohedral system, but the forms are quite distinct from those of quartz. It usually occurs in hexagonal tables, arranged in groups of three; whence the discoverer, von Rath, proposes to call the new mineral Tridymite. It is found in small sharply defined crystals, in the cavities of a porphyry, associated with iron-glance and hornblende, at Cerro S. Cristobal, near Pachuca, Mexico. Rath's description will be found in vol. cxxxiii. of 'Poggendorf's Annalen.'

(Graham, *Proc. Roy. Soc.* xiii. p. 335 [1864].)

SILURIAN SYSTEM. [E. C. vol. iv. cols. 770-774; GEOLOGY, E. C. vol. ii. col. 975 *et seq.*]. In the absence of any sound principles whereby to determine the vertical boundaries of the Silurian System of rocks, geologists vary amongst themselves as to the strata which ought to be considered its bottom beds. Thus Sedgwick has made the Wenlock beds the base of the Silurians [CAMBRIAN ROCKS, E. C. vol. i. col. 728]; Lyell and many others consider them to terminate downwards with the Llandeilo series, [GEOLOGY, E. C. vol. ii. col. 975]; and Murchison, who is followed by the officers of the Geological Survey, terminate them with the Lingula flags. [SILURIAN SYSTEM, E. C. vol. iv. col. 771.]

In this article the term Silurian System will be considered to mean all the strata from the Passage beds to the base of the Llandeilo formation; but for the sake of comparison we shall have occasion to allude more than once to the Lingula flags, which are to be considered as pre-Silurian. The following tabular view contains the latest opinions of Sir R. I. Murchison on the classification of the older Palæozoic strata.

UPPER SILURIAN.	LUDLOW GROUP.	*Passage Beds, Tilestone, and Downton Sandstone.*	A series of greenish grey shales, containing lenticular pockets of hard grey grit; with abundance of crustacean and plant remains, *Lingula cornea*, and fish fragments.
			Thin bedded yellowish sandstones with crustaceans (Pœcilopod), plant and fish remains, *Lingula cornea?* var. *minima* (Sow.), *Orthoceras*, *Platyschisma helicites*, *Modiolopsis*, *Beyrichiæ*, &c. Localities: Ledbury, Ludlow, Downton, Kington, Lesmahago.
		Upper Ludlow Rock.	Yellowish, greenish, and grey, argillaceous sandy mudstone with calcareous lenticular and nodular masses, and many species of Brachiopoda, *Chonetes lata*, *Rhynchonella nucula*, *Discina rugata*, *Orthis lunata*, and *O. elegantula*, with *Orthonota amygdalina*, *Serpulites longissimus*, &c. Loc.: Whitcliffe, Ludlow, Malvern, Longhope.

UPPER SILURIAN.	LUDLOW GROUP.	*Aymestry Limestone.*	Grey, pale yellow or brown shales, with bands of argillaceous limestone in the upper part, and containing great numbers of ***Strophomena filosa*, *S. depressa*, *Rhynchonella nucula*, *R. navicula***, and ***Lingula Lewisii***; the lower portion also consisting of beds of argillaceous limestone, filled with *Pentamerus Knightii*, *P. galeatus*, *Strophomena euglypha*, *Atrypa reticularis*, *Lingula striata*, with *Proetus Stokesii*, ***Phacops caudatus***, &c. Loc.: Whitcliffe, Aymestry, View Edge, Onibury.
		Lower Ludlow Shale.	Yellowish grey, hard flaggy and nodular argillaceous shales, with occasional beds of impure limestone, and containing concretionary nodules of fossiliferous blue limestone; the upper portion contains *Lingula lata*, *Graptolites **Ludensis***, and ***Cardiola interrupta***; in the middle portion ***Phragmoceras*** and ***Lituites*** occur; and in the lower ***Phacops***, &c. Loc.: Vinnal Hill, Mocktree, Stokes Wood, Onibury.
	WENLOCK GROUP.	*Wenlock Limestone.*	Argillaceous or semi-crystalline limestone, and lenticular masses of concretionary matter, abounding in organic remains, especially Crinoidea, Cœlenterata, Crustacea, and Brachiopoda; *Spirifera plicatella*, *S. elevata*, *Athyris tumida*, *Atrypa reticularis*, *Rhynchonella Stricklandii*, *R. borealis*, *R. Wilsonii*, *Orthis rustica*, *Strophomena antiquata*, *Discina Forbesii*, and ***Obolus Davidsonii***, being most typical. Loc.: Wenlock Edge, Dudley, Walsall, May Hill, &c.
		Wenlock Shale.	Hard flaggy beds and thin shales, in places slaty, with occasional beds of sandstone; fossils resembling those above. Loc.: Wenlock, Dudley, Walsall, Malvern, Usk, &c.
		Woolhope Beds.	Dark grey semi-indurated limestone, with much carbonate of lime in veins, and occasional bands of argillaceous nodules, &c., also sandy beds in places; ***Illænus* (*Bumastus*), *Barriensis*, *Orthis Davidsonii*, *O. elegantula***, var. Loc.: Woolhope, Walsall, &c.
		Denbighshire and Tarannon Slates.	Thin-bedded flaggy sandstones and slaty beds; fossils comparatively rare in places, especially in the gritty beds. Loc.: Flintshire, Denbighshire, Tarannon river banks, &c.
		Upper Llandovery.	Grey and yellowish sandstones (occasionally conglomerates) with bands of limestones, rich in organic remains, especially Brachiopoda; *Pentamerus oblongus*, *Rhynchonella*, *Orthidæ*, &c. Loc.: May Hill, Shelve, Tortworth, &c.
LOWER SILURIAN.		*Lower Llandovery.*	Hard sandstones, conglomerates, and flaggy shaly beds; the fossils closely allied to those of the Upper Llandovery series; but distinguished by *Pentamerus lens*, and by unconformity.
		Caradoc or Bala Beds.	Shelly sandstones, shales and slaty beds, with quartzose grits, conglomerates, and occasional limestone or calcareous bands; fossils numerous, especially Echinodermata, Crustacea (*Trilobites*), Polyzoa, and Brachiopoda; of the last nearly fifty [? 70] species, including *Orthis **Actoniæ***, and ***O. flabellulum***. Loc.: Caradoc, Hordesley, Norbury, Bala, Snowdon, Wexford, Kildare.
	LLANDEILO GROUP.	*Llandeilo Flags.*	Dark grey flagstones, occasionally calcareous, with black slates containing *Graptolites*, &c. The Llandeilo flags comprise two groups, Upper and Lower. ***Lingulæ*, *Obolellæ*, *Discinæ***, and ***Orthidæ*** occur in, and characterise this group of rocks with ***Ogygia Buchii*, *Asaphus tyrannus***, and ***Trinucleus concentricus***. Loc.: Llandeilo, Builth, Shelve district, Cader Idris, &c.
		Lower Llandeilo or Tremadoc Slates.	Dark grey and ferruginous slates, sandy shales, and hard bluish flags, with occasional bands of pisolitic iron ore, much felspathic matter in lines and thin beds; the Lower and Upper Tremadoc slates contain numerous genera of Trilobites, *Ogygia scutatrix*, ***Asaphus Homfrayi*, *Æglina***, *Trinucleus*, &c., also Heteropod and Pteropod Mollusca, &c., with Graptolites (***Diplograpsus pristis*** and *D. folium*), and *Orthis alata* and *O. testudinaria*. Loc.: Stiper Stones, Tremadoc, Portmadoc, Ffestiniog, Dolgelley, Dudreath, &c.
		Lingula Flags.	A great series of black and dark shales, grey and brown thin slaty flagstones and sandstones, with siliceous grits and quartzites (Stiper Stones), occasionally crowded with fossils, and always having the characteristic *Lingula* (*Lingulella*) ***Davisii***. It is equally remarkable for its Crustacea (***Paradoxides*, *Olenus*, *Agnostus*, *Hymenocaris***, &c.). Loc.: Dolgelley, Barmouth, Ffestiniog, St. Davids, &c.
CAMBRIAN ROCKS.			Dark green, grey, black and brown flags, also grits and conglomerates occurring at Harlech, Anglesea, Llanberris, St. Davids, the Longmynd, &c., with few fossils.
LAURENTIAN ROCKS,			"Fundamental gneiss" of Murchison. Western promontories of Ross and Sutherland, the Lewis, Lews or Long Island, including Harris and other parts of the Hebrides.

In the British Isles the superficial area over which the Silurian strata, together with the Lingula flags, are exposed is nearly 33,000 square miles. Of these 7600 occur in England and Wales, 18,420 in Scotland, and probably about 7000 in Ireland. The largest Silurian area is possessed by Scotland, which country is so largely formed of these rocks, that not more than one-third of its surface is composed of rock strata of earlier and later ages. On looking at a geological map of the British isles, the eye is at once struck by a certain general arrangement of the direction or strike of the outcrops of the various formations. They are predominantly south-easterly and north-westerly in the southern portions of the kingdom, if we exclude the Wealden area of Kent and Sussex. Towards the north the trend becomes more nearly N. and S. Throughout all this area the prevailing dip is towards the S.E. and E., so that in proceeding from E. to W. we generally pass from newer to older rocks. Hence with the exception of a few insulated patches all the Silurian rocks are developed in the extreme west. In England we traverse full developments of the tertiary and secondary strata in proceeding N.W., and the same thing happens in travelling along the eastern coasts. In Scotland the tertiaries and secondaries occur in a few scattered masses only; and the south-eastern shores of the southern half consist chiefly of the carboniferous strata. As the general strike is a little to the E. of N. and W. of S., and the average dip is easterly, it is in harmony with the prevailing structure of the whole island that the Silurian strata should form so large a proportion of the Scottish, and that they should occur almost everywhere but the S.E. corner. It is also in accordance with this structure that they should rest upon older rocks in the N.W., which rocks are now known to be the oldest in the British Isles. These last have been assigned to the Laurentian series, and are to be met with at the places mentioned in the foregoing table. In Wales, however, or rather in the country to the west of the Longmynd, the Abberley, the Malvern, and the May Hill ranges, there is an important difference in the general strike and dip; the strata are thrown into vast undulations, are broken by numerous faults of enormous throw, and are arranged in the form of a basin (or rather half a basin), the fragmentary edges of which are composed of the older Cambrian series. These are the general features, which are not at all disproved by the fact that there are a few inliers of Cambrian rocks, as well as outliers of old red sandstone, carboniferous limestones, coal measures, and Permian in the various parts of the basonic area. Details justifying these general remarks will be given in the sequel; but for the present it will suffice to say that the edge of this basin or bay follows a curvilinear line from St. Bride's Bay to Usk, the Malverns, the Longmynds, and Denbighshire.

The Llandeilo series is an enormous mass of deposits, which, in Shropshire, has been estimated to have a thickness of 14,000 feet. Sir R. Murchison divides it stratigraphically into Llandeilo flags and Lower Llandeilo, in the foregoing table; but in his 'Siluria' this division is not generally indicated, while the former is treated as though it were the same from top to bottom. It is very probable, however, that there are three distinct formations, that is, three series of rock strata, each of which is marked by its own peculiar fauna, and which have few species in common. They have been named in various ways. The lowest is known as the Tremadoc slates, the Arenig group, the Skiddaw group, and Lower Llandeilo. The second is the Llandeilo flags of Wyatt-Edgell. And the third is the Upper Llandeilo flags of Wyatt-Edgell, and the upper portion of the Llandeilo flags of Murchison. In Shropshire the siliceous grits of the Stiper stones are overlain by slightly micaceous grey flagstones, which acquire a brownish colour by weathering. These alternate with beds of a darker colour, and more schistose character. The whole series has the same strike (N.N.E.) and the same dip (N.N.W.) as the Stiper stones, and their thickness is estimated at about 3000 feet. Fossils occur in the flagstones, but are more abundant in the black earthy slates. The more characteristic species occurring here are:—*Obolella plumbea*, *Redonia Anglica*, *Ribeiria complanata*, *Orthoceras Avelinii*, *O. encrinale*, *Æglina binodosa*, *Trinucleus Murchisoni*, and Encrinites. In North Wales, as for example, near Manod Bach, sandstones probably belonging to the Upper Lingula flags pass up into others of a more flaky and micaceous character, which are interbedded with thin flaky slates. Farther to the west, as in the Penrhyn peninsula, and near Arenig-bach, the slates acquire a greater and the sandstones a less proportional development. They are also much interbedded with volcanic ashes and porphyries, whereby their aggregate thickness is enormously increased, although the purely sedimentary portions are probably not nearly so thick as the corresponding portions further east. Amongst the fossils cited from these beds may be mentioned:—*Orthis calligramma*, *Ogygia Selwynii*, *Calymene parvifrons*, var. *Murchisoni*, *Æglina grandis*, *Trinucleus Gibbsii*, and *Lingulella Davisii*. In Whitesand Bay, near St. Davids Head, the Lingula flags graduate upwards into dark-coloured schists and slates, which contain *Ogygia peltata*, *Trinucleus Gibbsii*, and *Agnostus pisiformis*. Above these are black schists which belong to the Llandeilo flags.

The Lower Llandeilo flags consist of black shales and white sandstones near Builth in Radnorshire, and near Wellfield. Farther west, as at Llandeilo, in Carmarthenshire, and at Narberth in Pembrokeshire, it is chiefly composed of flaggy sandstones, and large beds of limestone. Wherever exposed they contain *Asaphus tyrannus*, *A. peltastes*, *Ogygia Buchii*, var. *convexa*, *Calymene cambrensis*, *Trinucleus favus*, *Lichas patriarchus*, *Bellerophon bilobatus*, *Lingula granulata*, *L. attenuata*, and *Orthis striatula*.

The Upper Llandeilo flags occur at Builth, and at Abereiddy Bay; they consist of dark slates and black graptolitic shales. The commoner graptolites, such as *Didymograpsus Murchisoni*, and *Diplograpsus pristis*, being more especially abundant in the bottom beds. The fauna comprises, in addition to the Graptolites just mentioned, *Asaphus corndensis*, *Ogygia Buchii*, ordinary var.; *Barrandia Cordai*, *B. radians*, *B. longifrons*, *B. Portlockii*, *Calymene duplicata*, *Trinucleus fimbriatus*, *Cheirurus Sedgwickii*, *Ampyx nudus*, *Agnóstus Maccoyi*, *Lingula Ramsayi*, *Bellerophon perturbatus*, *Murchisonia simplex*, *Modiolopsis inflata*.

The igneous rocks are developed most largely in the Lower Llandeilo flags, and occur in greater or less abundance in most parts of Wales. In the Shelve and Corndon district, for example, there are numerous seams or beds of felspathic ashes between the west flank of the Stiper stones and Marrington Dingle, near Chirbury. In the space of about 45 square miles, in the neighbourhood of Hyssington, there are 17 of these seams. They alternate with schists and shales, and in consequence of their superior hardness they appear as conspicuous ridges. In addition to these, there are beds of a more massive character, which are described by Murchison as being felspathic agglomerates, and slaty porphyries with crystals of felspar. These alternate with schists containing Trilobites, while fragments of organic remains have even been found in the midst of beds entirely composed of volcanic matter; *Ogygia Buchii* is amongst the fossils thus represented. Similar phenomena occur in all the hilly districts, extending from Llandegly to Carneddau and Builth. The intrusive rocks are chiefly coarse-grained greenstones and felstones. In North Wales the volcanic phenomena are displayed on a still larger scale, and under such circumstances as to indicate that the volcanic deposits were formed under the same conditions, and at about the same time, as those just alluded to.

These igneous rocks are similar to those of the eastern district, and are of two kinds, which Professor Ramsay terms eruptive and contemporaneous, which words are used by him for want of more precise ones. By eruptive is meant "all those bosses, dykes, &c., not surface lavas, that lie among the other rocks, and may even in some cases consist of parts of the strata amid which they lie, that have themselves been melted." And the word contemporaneous is meant to imply that these rocks "were poured out as lava or showered abroad as ashes, in general terms, contemporaneously with the formation of the strata amid which they immediately lie." These eruptive rocks are considered to be of two kinds, viz. (1), felspathic and quartz porphyries and syenite, and (2) greenstones. And the contemporaneous rocks also are grouped into two divisions, according as they are (1) felspathic porphyries or lava beds, or (2) felsphathic and calcareous volcanic ashes. The great bulk of these ash beds occupies a low horizon in the Llandeilo flags, and they are thickest in particular spots. Thus at Cader Idris the ashes have a thickness of 3300 feet, an E. and W. strike, and a southerly dip. They are described by Selwyn as being vesicular, calcareous and felspathic ashes, interstratified with arenaceous and felspathic slaty beds, themselves generally more or less ashy, and sometimes conglomeratic and brecciated. Near their upper boundary is a band of blue slate, nearly 100 feet thick, which passes to the east. Above this band is an enormous mass of felspar porphyry. On tracing the ash beds towards the S.W., they are seen to gradually thin out as we approach the coast, and almost disappear near Llanegryn. Near Dolgelly the igneous rocks retain the same stratigraphical position; the vesicular, calcareous, and conglomeratic ashes are surmounted by the blue slaty band, which itself underlies the porphyry, or, rather, porphyry-like rock; for although porphyritic, Professor Ramsay says it is readily distinguishable from a genuine crystalline porphyry, "for its crystals look, not as if separated from the matrix during the process of cooling, but rather as if they had been showered out along with, and mechanically embedded in, an ashy paste. They are, besides, often broken, and pebble-like fragments and slaty flakes occur in the enveloping spathose matter." In the Arran range vesicular volcanic ashes, like those at Dolgelly and in the Cader Idris district, underlie a felspar porphyry. They are, however, chiefly felspathic and rarely calcareous. They are also more streaky, owing to the occurrence of lenticular patches of coarse felspathic volcanic conglomerate, containing both rounded and angular fragments, the rounded ones owing their shape apparently to the action of water. There are a few beds of slate interstratified with the ashes. The thickness of the whole series here is about 3300 feet. Further north the porphyry and ashes rapidly thin off, for at Moel Dhu their thickness has diminished to about 1100 feet. At Drws-y-nant-isaf felspathic and calcareous ashes underlie the felstones, while above them a second series of ashes commence near Penmaen, and reach a considerable thickness (700 or 800 feet) in the Arenigs, and dip towards the east. They are barely perceptible in the higher summits of the Arrans and at Cader Idris, and as we proceed north they increase in thickness, while the lower ashes gradually thin away, and are only represented by a few unimportant streaks in the country north of Moel-llyfn-nant. The upper ashes occupy a considerable extent of ground in the neighbourhood of Arenig, but die off towards the E. and N. From these, and other facts not mentioned here, we gather that the lavas and volcanic ash deposits are chiefly developed along a curvilinear line from near the mouth of the river Dovey to within a short distance of the Snowdon area, and that they are accumulated about certain centres, such as Cader Idris, Arran Mowddy, and other elevated peaks, from which they thin out as we recede from such points. From their mode of arrangement, from the frequent evidence of a rude kind of stratification, and from the occasional presence of fossils, we seem to see plain evidence that in the earlier period of the Llandeilo flag submarine volcanoes were constantly pouring forth streams of lava and showers of ashes. There are also igneous or volcanic rocks at and around Snowdon, but these were formed at a later period, or during the deposition of the Caradoc series of strata.

The Llandeilo series are entirely absent all along the eastern border of the Silurian area, and apparently they were never deposited so far east. Thus at Wenlock Edge the Caradoc beds rest on the old Cambrian grits; at the Malverns, Lower Llandovery conglomerates rest upon beds of Lingula flag age; and at May Hill, Upper Llandovery beds rest upon Harlech grits. In all these cases, therefore, the Llandeilo series is entirely unrepresented.

Passing now to the Caradoc or Bala beds, we find that they consist mainly of clays and sands, with occasional bands of limestones. The sands are most developed towards the eastern borders, while the argillaceous and calcareous deposits are most developed in the more central portions of Wales. In Shropshire the lowest beds are sandy shales with bands of sandstone so filled with shells as to have a strong calcareous nature; these are succeeded by light-coloured, yellowish sandstones, which pass into coarse grits in places, such as for instance the sharp ridge of Hoar Edge. Above these are shale, followed by sandstones, which, like those at a lower level, are rendered more or less calcareous by the abundance of shells contained in them. These sandstones are remarkable for their soft and sectile character, one rarely met with amongst strata of such high antiquity. The higher part of these beds is marked by a flag-like laminated structure, and is exceedingly fossiliferous. It passes up into earthy shales abounding in *Trinucleus concentricus*. The more abundant fossils in the lower portion of the Shropshire Caradocs are:—*Diplograpsus pristis*, *D. foliaceus*, *Orthis calligramma*, *O. testudinaria*, *Lingula attenuata*, *Palæarca elongata*, *Orthonota nasuta*, *Ctenodonta varicosa*, *Theca triangularis*, *Beyrichia complicata*, *Trinucleus concentricus*. In the higher beds the most abundant species are *Calymene Blumenbachii*, *Homalonotus bisulcatus*, *Phacops truncato-caudatus*, *Tentaculites Anglicus*, *Orthis vespertilio*, *O. elegantula*, *Strophomena*, a species like *S. grandis*, *S. tenui-*

striata, *S. bipartita*, *Leptæna sericea*, *L. transversalis*, *Modiolopsis orbicularis*, *Ctenodonta varicosa*, *Bellerophon bilobatus*, and *B. acutus*. Associated with the last, though less common, are *Lichas laxatus*, *Cornulites serpularius*, *Discina oblongata*, *Orthis Actoniæ*, *O. biforata*, *Murchisonia simplex*, *Cyclonema crebristria*, and *Cornularia Sowerbyi*. In the highest shales *Trinucleus concentricus* is particularly abundant. These same beds are continued westwardly, appearing at intervals in the undulations of the strata, and forming the summit of Snowdon, in which district they are largely interbedded with volcanic rocks. It is owing to this circumstance that the actual distance between the lowest and highest beds of the series are farther apart in North Wales than in Shropshire, although in the latter area the sandstones and shales are about 4000 feet thick, while the limestones and sandstones forming the Caradoc series at Bala and to the west of it are not more than 1050 feet thick. In North Wales the Caradoc sandstones are finer, and the limestones are thicker, indicating a greater average depth of water. It is also to be noticed that the west beds are harder, and seldom present the soft and occasionally mud-like character of some of the Shropshire strata. The Caradoc beds occupy a very wide superficial area in South Wales, in consequence of the slight general dip of the strata, and the numerous undulations into which they have been thrown. The Caradoc beds thin out rapidly towards the southern edge. Thus from the right bank of the Towy to Mynydd-y-ffair the Llandeilo schists pass into more arenaceous beds with occasional calcareous courses, and these pass by pebbly beds into Llandovery rocks. These arenaceous beds represent the Caradoc formation, and are of inconsiderable thickness. Proceeding a little to the N. of W. to Cwm-y-gwern, the Llandeilo is overlain by sandy shales with calcareous courses containing Caradoc fossils, such as *Trinucleus seticornis*, *Staurocephalus Murchisoni*, *Orthis insularis*, *O. Actoniæ*, *O. vespertilio*, *O. calligramma*, *Leptæna transversalis*, *L. quinquecostata*, *L. tenuicincta*, *Cyclonema crebristria*, *Halysites catenulatus*. Farther north, or in Cilgwyn Park, the Llandeilo beds are dark earthy slates, containing such Caradoc fossils as *Trinucleus seticornis*, *Asaphus Powisii*, *Illænus Bowmanni*, *Orthis spiriferoides*, *O. biforatus*, *O. insularis*, *Bellerophon bilobatus*, *B. nodosus*, *Theca triangularis*, *Sphæronites balthicus*, and *Pleurocystites*. Caradoc beds appear beneath the Llandovery at Blaen-y-cwm, south of Llandovery, and farther north between Rhayader and Builth. They also occur to the west of Llandeilo, as at Llanpeter Felfry in Pembrokeshire, and at Sholeshook near Haverfordwest, and they are well developed throughout the vast area comprised by the counties of Carmarthen, Cardigan, Radnor, and Montgomery, covered in places by Llandovery deposits. On the other hand, the Caradoc beds are not represented in the Malvern Hills, where, as has already been stated, the Lingula and Upper Llandovery beds occur in close contiguity ; nor in the May Hill district ; nor in several districts of limited area in Shropshire and Radnorshire. The evidence, therefore, indicates that the Caradoc series never extended so far S.S.E. and probably E. as the underlying Llandeilo and overlying Llandovery rocks ; and that in certain areas of Shropshire and Radnorshire the deposits of the Llandeilo period were elevated in places above the sea level of the Caradoc period. On the whole, the sea appears to have retreated somewhat westwardly in the area under notice ; but it made a temporary inroad towards the east in the Wenlock district. The general upward transition from shales and fine sands into coarse grits and conglomerates also points to a shallowing of the water and encroachment of the land towards the west.

The Llandovery series is divided into the Upper and Lower. The land underwent great changes during the period of their deposition, and more especially during the middle part of this period. The marked distinction between the two halves does not seem to depend upon unconformity, but upon the fact that the Lower Llandovery follows the general strike and dip of the subjacent Silurian beds, while the Upper Llandovery partakes of the general N.E. strike and S.E. dip which prevails throughout the Upper Silurian and the great majority of subsequent deposits. The Lower Llandovery appears to have had its eastern boundary on the western flanks of the land stretching from the Longmynds in the north to the Malverns and May Hill in the south, whereas the shore edge of the Upper Llandovery terminated westwardly, along the eastern borders of Wales, while its continuation in the opposite direction indicates recession from the ancient shore line. The changes which occurred were evidently very great, but we are not in a position yet to fully comprehend their nature and extent. They do not, however, appear to have been accompanied by a corresponding change in the organic world, for most of the Llandovery species range from the bottom to the top strata. The phenomena appear to be of purely local importance ; so that although it may be convenient to group the Lower Llandovery with the Lower Silurian, and the Upper Llandovery to the Upper Silurian upon stratigraphical grounds, we believe these reasons will only be of force in the district before us, and that the examination of the Llandovery series in other countries, together with its general palæontological character in all countries, do not seem to warrant this division of the series. There is only one place in England and Wales where the relations of the Upper and Lower Llandovery to each other, and to the beds above and below them, are shown, viz., Noeth Grug, which is a few miles north of Llandovery. There the Upper Llandovery lies to all appearance conformably upon the Lower Llandovery, and both occur in a synclinal fold, with a S.W. and N.E. strike, and underlain by Caradoc beds. This fold is, however, abruptly terminated on the S.E. by a fault, which is immediately succeeded by Upper Llandovery and the Upper Silurian strata. In the Lower Llandovery of Noeth Grug the following, among other fossils, have been obtained :—*Illænus Bowmanni*, *Lichas laxatus*, *Murchisonia simplex*, *Orthis insularis*, *O. calligramma*, *O. Actoniæ*, *Strophomena bipartita*, *Leptæna sericea*, *Cyclonema crebristria*, *Lituites cornu-arietis*, *Orthoceras bilineatum*, *Atrypa marginalis*, *Orthis elegantula*, *O. occidentalis*, *Strophomena antiquata*, *S. pecten*, *Conularia Sowerbyi*, *Bellerophon dilatatus*, *Orthoceras ibex*, *Orthis reversus*, *Rhynchonella furcata*, *R. angustifrons*, *Raphistoma tubercularis*, *Petraia subduplicata*, and *P. elongata*. On the eastern flanks of the Longmynds the Upper Llandovery, represented by a coarse conglomerate, rests uncomformably upon Cambrian rocks, and dips S.E. Farther S.E. it appears in a conformable position, and retaining its dip in the same direction, between Caradoc and Wenlock beds. The most characteristic fossils in it here are *Pentamerus oblongus*, *P. lens*, *Atrypa hemisphærica*, *Rhynchonella decemplicata*, *Strophomena compressa*, *Leptæna sericea*, *Orthis calligramma*, *O. biforata*, *Cyclonema crebristria*, &c. On the banks of the Onny the Llandovery is represented by a thin calcareous band ; on tracing it north-easterly, or towards the Wrekin, the series acquires a greater thickness, being increased in bulk by the interposition of sandstones and conglomerates beneath the limestone bed, whose characteristic fossil is *Rhynchonella decemplicata*. It continues as far as the Wrekin and Buildwas. When followed towards the S.W. the Llandovery occurs as a quartzose pebbly conglomerate, passing into a hard coarse grit at Corton, and as a siliceous grit and conglomerate in Radnorshire. The Upper Llandovery occurs as a sandstone and conglomerate, containing *Pentamerus*, on the west flanks of the Malverns, where it rests upon Lingula flags, and, like all the Silurian rocks in this district, it has a N. and S. strike, with a dip to the west at a high angle. The thickness is estimated at 600 feet. The usual fossils are *Pentameri*, *Atrypa hemisphærica*, *Rhynchonella decemplicata*, *Petraia subduplicata*, *Orthis calligramma*, *Ctenodonta Eastnori*, *C. subæqualis*, *Bellerophon trilobatus*, *Holopella obsoleta*, *Lingula crumena*, and species of *Pterygotus*. A small patch of Upper Llandovery occurs in the Woolhope valley, and it is also represented at May Hill and at Huntley Hill. At Huntley Hill the series consists of purple and green shales and sandy beds, which pass into hard, coarse grits, and yellowish fine micaceous sandstones. On the whole, they dip steadily towards the W.N.W., and contain *Atrypa hemisphærica*, *Orthis calligramma*, *Rhynchonella decemplicata*, with *Pentameri*. These are succeeded by light grey sandstones and grits, with *Pentameri*-like shells, such as *Stricklandinia lens* and *S. lineatus*, associated with *Atrypa reticularis*, *Strophomena pecten*, and *S. arenacea*. Farther to the S., or in the Tortworth district, the oldest visible rock is an Upper Llandovery sandstone. Strata of similar age occur in the easternmost developments of the Silurian strata, as in the lower Lickey Hills, in Worcestershire, and near Barr, in Staffordshire. At Lickey they are quartzites, which graduate upwards into coarse grits and sandstones, in which *Stricklandinia lens* occurs. To the E. and S. of Lickey, as at Colmar and Kendal End, these sandstones are surmounted by Lower Wenlock shales and limestones.

The Wenlock group, which is so profuse in forms, individually, specifically, and generically, presents great variation in its lithological character, including, as it does, shales, limestones, and sandstones. Its beds are best developed along the border lands of England and Wales. In proceeding from N. to S. along this area, the lowest Wenlock strata are coarse sandstones in the N., shales and finer sandstones in the middle district, and limestone in the S. In most places, they rest upon Llandovery rocks, and dip S.E. In Denbighshire, and at Marloes Bay, the bottom Wenlock beds are sandstones, which are called Denbighshire grits, at Noeth Grug and in Radnorshire they form the Tarannon shales, while on the flanks of the Malverns the Woolhope limestone is the lowest part of the Wenlock formation. The strata also indicate a transition from shallow to deeper water in passing towards the east; and in connection with this it is noticeable that whereas in Shropshire the Wenlock group rarely exceeds 1000 feet in thickness, its dimensions are more than doubled in N. Wales, since it is almost always the case that in contemporaneous deposits those deposited in the deeper water are far less thick than those formed nearer shore or in shallower water. The Denbighshire grits and Tarannon shales are confined to comparatively limited areas. The lowest widely spread Wenlock strata are the Woolhope beds, which are generally thick bedded limestones, which are interbedded with argillaceous bands in some places, and sandy ones in others. The limestones are thicker in Radnorshire than in Shropshire, and in these counties contain *Bumastus Barriensis*, *Phacops caudatus*, *Encrinurus variolaris*, *Leptæna lævigata*, *Acroculia prototypa*, *Pentamerus Knightii*, *Atrypa hemisphærica*, *Staurocephalus Murchisoni*. At Woolhope these beds are represented by limestones and shales, in which the chief fossils are *Bumastus Barriensis*, *Homalonotus delphinocephalus*, *Phacops caudatus*, *Cornulites serpularius*, *Orthoceras annulatum*, *Euomphalus sculptus*, *Spirifer elevatus*, *Strophomena imbrex*, *S. pecten*, *S. depressa*, *Leptæna transversalis*, *Orbiculoidea Forbesii*, *Atrypa reticularis*, *Rhynchonella Wilsoni*, *Orthis elegantula*. At May Hill, in the Malvern district, on the flanks of the Lickey Hills, Worcestershire, and in the Barr District, Staffordshire, the Woolhope beds are represented by somewhat similar strata, containing the same group of fossils. The Wenlock shale is an upward development or continuation of the shales in the Woolhope beds. It is well developed from Coalbrook-dale in the north to the Malverns in the south. In Denbighshire it is represented by hard slaty sandstones, in Shropshire by argillaceous shales, which become finer in texture and more calcareous as they are followed southwards. In a few spots, however, they are somewhat sandy and gritty. The principal fossils in this division of the Wenlock group are :—

Orthis elegantula.
Strophomena pecten.
S. depressa.
Atrypa marginalis.
A. reticularis.
A. tumida.
Spirifer plicatellus.
Orthis biloba.
O. hybrida.
O. rustica.
Leptæna depressa.
L. transversalis.
Pentamerus linguifer.
Rhynchonella rotundata.
R. depressa.
R. Stricklandi.
R. deflexa.
R. sphærica.
R. navicula.
Cardiola interrupta.
Euomphalus funatus.
E. alatus.
Pileopsis haliotis.
Bellerophon wenlockensis.
P. dilatatus.
Theca Forbesi.
T. anceps.
Orthoceras subundulatus.
O. primævum.
Lituites articulatus.
L. Biddulphii.
L. giganteus.
Encrinurus punctatus.
E. variolaris.
Calymene Blumenbachi.
C. tuberculosa.
Phacops caudatus.
P. longicaudatus.
Cornulites serpularius.
Favosites alveolaris.
F. fibrosus.
Graptolithus priodon.

The Wenlock limestone, the highest member of the Wenlock group, occurs in thick beds, which differ from those of the Woolhope limestone in having a highly concretionary structure. The concretions are frequently many feet in diameter, and are more purely calcareous than the non-concretionary part of the limestone. These concretions, or " ballstones," as they are called, may be well seen near Wenlock. The limestone thins out rapidly from Wenlock towards the S.W., and on the banks of the Sugg a few calcareous concretions are all that represent it, while in Radnorshire and in Marloes Bay it can scarcely be traced. It is absent in the other parts of Pembrokeshire, and throughout the counties of Brecon and Carmarthen. It is, however, well developed in the east, as in the Malvern, Woolhope, May Hill, and Usk districts. The well-known Dudley limestone of Castle Hill and the Wren's Nest, is the same as the Wenlock limestone. The species found in this limestone are exceedingly abundant ; the most important of them are :—

Halysites catenularius.
Favosites fibrosus.
F. asper.
F. cristatus.
Heliolites interstinctus.
H. tubulatus.
H. petaliformis.
Strophomena euglypha.
S. filosa.
S. depressa.
Pentamerus galeatus.
Spirifer plicatellus.
S. trapezoidalis.
S. crispus.
Cœnites juniperinus.
Syringopora bifurcata.
Omphyma turbinata.
O. subturbinata.
Alveolites Labechei.
Cyathophyllum truncatum.
C. articulatum.
Acervularia luxurians.
Periechocrinus moniliformis.
Orthoceras annulatum.
O. Brightii.
Bellerophon dilatatus.
B. wenlockensis.
Conularia Sowerbyi.
Euomphalus carinatus.
E. sculptus.
E. discors.
E. funatus.
E. rugosus.
Orthonota cingulata.
Avicula reticulata.
Pterinea retroflexa.
P. planulata.
Spirifer elevatus.
Orthis rustica.
O. elegantula.
O. hybrida.
Leptæna transversalis.
L. lævigata.
Atrypa reticularis.
A. marginalis.
Retzia cuneata.
R. Salteri.
Rhynchonella borealis.
R. Wilsoni.
R. nucula.
Calymene Blumenbachi.
Encrinurus punctatus.
E. variolaris.
Phacops Downingiæ.
P. Stokesii.
P. caudatus.
Acidaspis Brightii.
Bumastus Barriensis
Homolonotus delphinocephalus.
Cornulites serpularius.
Tentaculites ornatus.

The Ludlow group is the highest member of the Silurian series ; it usually dips towards the S.E., the variations therefrom being due to local anticlinals, as at Woolhope, and it generally succeeds the Wenlock beds. Its lithological character is largely argillaceous, and its lower shales closely resemble those of Wenlock age. There are a few local developments of limestones in the lower portion, while in the upper half sandstones are largely predominant, which pass up gradually and apparently conformably into the old red sandstone. The Lower Ludlow shale ranges from Shropshire by Presteign to Radnor Forest, being overlain throughout a large portion of the tract by the Aymestry limestone ; it thence spreads through Montgomeryshire and Brecknockshire, without any overlying limestone. It is exposed in the Malverns, at Woolhope, near Usk, and in Staffordshire, in all which places it is associated with the Aymestry limestone. Its usual fossils are :—*Protaster Miltoni*, *Palæocoma Marstoni*, *P. Colvoni*, *Orthoceras Ludense*, *O. filosus*, *O. subundulatus*, *Lituites giganteus*, *Cardiola interrupta*, *C. striata*, *Orthonota rigida*, *Pterinea retroflexa*, *Pentamerus galeatus*, *Strophomena depressa*, *S. euglypha*, *Leptæna lævigata*, *Atrypa reticularis*, *Rhynchonella Wilsoni*. The Aymestry limestone is generally a subcrystalline earthy limestone, of a bluish grey colour on the fresh surface of fracture. Its predominant fossil is *Pentamerus Knightii*, associated with *Rhynchonella Wilsoni*, *Lingula Lewisii*, *Strophomena euglypha*, *Atrypa reticularis*, *Bellerophon dilatatus*, *Pterinea Sowerbyi*. Above the Aymestry limestone there are thick masses of calcareo-argillaceous strata, which readily disintegrate, and hence have been called mudstones. It frequently abounds in small spheroids and concretions of sandy clay, which readily weather out, leaving the surface of the cliff or outcrop spotted with shallow depressions. These form the Upper Ludlow rock, and contain a multitude of fossils, such as, for instance :—

Chonetes lata.
Orthonota amygdalina.
Goniophora cymbæformis.
Pterinea lineatula.
P. retroflexa
Discina rugata.
Orthis elegantula.
O. lunata.
Rhynchonella nucula.
Cyclonema corallii.
C. octavia.
Serpulites longissimus.
Cornulites serpularius.
Beyrichia Walckensiana.
B. Klœdeni.
Alveolites fibrosus.
Orthoceras bullatum.
Phacops caudatus.
Encrinurus punctatus.
Calymene Blumenbachi.
Homalonotus Knightii.

The Downuton Sandstone and Passage beds are well exposed all along the eastern and southern margin of the Silurian area, and are, as at Ledbury, Usk, Ludlow, Trecastle, Narberth, Marloes Bay, &c., for the most part sandstones. In places they pass up so gradually into the old red sandstone, that it has been found difficult to decide where the boundary line is. Towards the lower portion grey marls and sandstone prevail, having only a few red bands interbedded with them, while towards the upper part the red marls and sandstone acquire the predominance. Fish occur in these strata, and are particularly abundant in two thin bands, the lowermost of which has long been known as the Ludlow bone bed. The latter vary from a quarter of an inch to four inches in thickness, and appear like a mass of small chocolate-coloured or even black fish bones, associated with the remains of shells and crustaceans. The fish-remains generally consist of scales and fin rays. The bone bed has been found at Broek Hill and Hales Hill, near Malvern, at May Hill and Huntley Hill, at Pyrton Passage on the Severn, at Onibury, at Hagley Park, as well as at Ludlow; so that it probably has a length of nearly 60 miles. At Bradnor Hill, near Kington, and at May there is a second bone bed somewhat higher than the Ludlow bone bed. The fossils in these beds are *Leptocheles Murchisoni*, *Pterygotus problematicus*, *Cephalaspis Murchisoni*, *Platyschisma helicites*, *Lingula cornea*, &c.

The life of the Silurian epoch, or rather the present state of our knowledge respecting it, is admirably displayed in Dr. Bigsby's 'Thesaurus Siluricus,' in which he has brought together in methodical arrangement the long muster-roll of the organic world, indicating the geological horizon and geographical distribution of every species. The list is grouped in classes, and the names under each class are arranged in alphabetical order, so that before a clear idea can be obtained as to the distribution of the groups in space and in time the inquirer is obliged to spend much labour in rearranging the names. We should have liked to have performed the task for the purpose of this article, but it would consume far more time than we can afford. The following list, however, will serve as a substitute for that in the original article. It includes all the forms belonging to the Silurian period in its widest sense. We have adopted Dr. Bigsby's arrangement, although in many cases it is not in accordance with the present prevalent opinions; in several instances Dr. Bigsby has himself pointed out that some of the genera which he has placed in one class more properly belong to another. The figures represent the number of species, except in the *Trilobita*, *Lamelli-branchiata*, *Gasteropoda*, and *Cephalopoda*, where they represent the appearances.

	America.	Europe.	Other Countries.	Common.
PLANTÆ.				
Actinophyllum . .	—	1		
Arthrophycus .	2			
Beatrices . . .	2			
Buthotrephis . .	12	2		
Dictyolites . .	1			
Ichnophycus . .	1			
Laminarites . .	—	1		
Lepidostrobus .	—	1		
Licrophycus . .	7			
Nullipora . .	—	1		
Palæochorda . .	2	3		
Palæophycus . .	18	1		
Palæotrochus . .	2			
Phycodes . .	—	1		
Phytopsis . . .	2			
Rusophycus . .	5			
Sphenothallus . .	2			
Spongarium . .	—	4		
Trichoides . . .	—	1		
Vexillum . .	—	3		
	56	20		None.
PROTOZOA.				
Acanthospongia . .	—	1		
Achilleum . .	—	2		
Amphispongia . .	—	1		
Archæocyathus .	4			
Astræospongia . .	1	1		
Astylospongia .	6	5	—	2
Calathium . .	7			
Caunopora . .	1			
Cliona . . .	—	3		
Cnemidium . .	—	3		
Coscinium . . .	2	1	—	1
Coscinopora . .	1			
Dædalus . . .	—	4		
Bospongia . .	2			
Intricaria . . .	1	1		
Ischadites . .	1	8		
Manon . . .	—	4		
Nidulites . .	—	1		
Palæomanon . .	1			
Protospongia . .	—	4		
Receptaculites . .	18	4	1	
Reticulites . .	—	2		
Rhabdaria . . .	2			
Scyphia . . .	—	3		
Siphonia . . .	3	2	—	1
Sphærospongia .	—	1	4	
Stromatopora . .	8	4	—	1
Stromatocerium .	1	1	1	1
Tetradium. . .	5			
PROTOZOA—*continued.*				
Tetragonis . .	2	5		
Trachium . . .	2			
Trichospongia .	1			
Verticillipora . .	—	1		
	69	62	6	6

There are some 20 or more species of rhizopods, but the generic and specific determinations are very doubtful.

CŒLENTERATA.				
Actinozoa.				
Acervularia . .	—	4		
Alveolites . . .	2	10	—	2
Amplexus . .	2			
Anisophyllum . .	1			
Arachnophyllum .	1	1		
Astrocerium . .	4	2		
Aulacophyllum .	—	1		
Bolpoporites . .	1	5		
Calceola . . .	3	2		
Callopora . . .	6			
Calophyllum . .	1			
Calopœcia . . .	3			
Campophyllum .	—	1		
Cannopora. . .	1			
Chætetes . .	17	11	1	1
Chonophyllum . .	1	1		
Cladopora . .	7			
Clathropora . . .	3			
Clisiophyllum .	3	5		
Cœnites . . .	5	10		
Columnaria . .	13	2	—	1
Conophyllum . .	1			
Constellaria . .	1			
Corynoides . .	—	1		
Cyathaxonia . .	—	2		
Cyathophyllum. .	13	10	—	1
Cyclolites . .	1			
Cylindropora . .	—	2		
Cystiphyllum .	4	8		
Dania . . .	1			
Dekayia. . .	1			
Dendropora . .	—	1		
Dianulites . .	—	2		
Diphyphyllum . .	1			
Diplophyllum .	4	1		
Discophyllum . .	2			
Emmonsia . .	2			
Enallopora . .	—	1		
Eridophyllum .	1	1		
Favistella . . .	6	1		
Favosites . .	18	16	2	6
Fistulipora . .	—	1		
Fletcheri . .	—	1		
Goniophyllum . .	—	3		
Halysites . .	5	8	—	3
Heliolites . . .	14	20	1	5
Helopora . .	15	1		
Heteropora . .	—	1		
Labechia . .	1	3		
Laceripora . .	—	1		
Lithostrotion . .	—	1		
Lonsdaleia . .	—	1		
Lyellia . . .	3			
Millepora . . .	—	3		
Myriolites . .	—	1		
Nebulipora . .	2	6	1	
Oldhamia . .	—	4		
Omphyma . . .	3	8		
Orbipora . .	—	2		
Pachyphyllum . .	—	1		
Palæocyclus . .	—	5		
Palæophyllum . .	—	1		
Petraia . . .	13	16	1	1
Phacites (?) . .	1			
Plasmopora . .	2	2	—	1
Propora . . .	1	1	—	1
Protarea . .	2			
Ptychophyllum . .	4	1		
Rhinopora . .	4			
Rhizophyllum . .	—	1		
Sarcinula . .	2	1		
Stauria . . .	1	1	—	1
Stellipora . .	1			
Stenopora . . .	15	9	1	2
Strephodes . .	2	7		

	America.	Europe.	Other Countries.	Common.
Actinozoa—continued.				
Streptelasma . .	5	1		
Striatopora . .	1			
Strombodes . .	5	5	—	1
Syringophyllum .	—	1		
Syringopora . .	18	16	—	4
Thecia . . .	2	7	—	1
Thecostegites . .	1			
Zaphrentis . .	17	6	—	1
	269	249	8	32
ANNULOSA.				
Echinodermata.				
Crinoidea.				
Actinocrinus . .	6	3	1	
Aspidocrinus . .	3			
Asterocrinus . .	1	2		
Balanocrinus . .	1			
Blastoidocrinus . .	1			
Brachiocrinus .	1			
Calliocrinus . .	—	1		
Calyx . . .	—	1		
Carabocrinus . .	3			
Caryocrinus . .	6	1		
Cheirocrinus . .	2	6		
Cleiocrinus . .	3			
Closterocrinus . .	1			
Coccocrinus . .	1			
Condylocrinus . .	—	1		
Cophinus . .	—	1		
Coronocrinus . .	1			
Crotalocrinus . .	1	1		
Cryptocrinus . .	—	2		
Ctenocrinus . .	—	4		
Cupellæcrinus . .	9			
Cupressocrinus .	—	1		
Cyathocrinus . .	5	6	1	
Cyclocrinus . .	2	1		
Cystocrinus . .	1			
Cytocrinus . .	1			
Dendrocrinus . .	12			
Dictyocrinus . .	1			
Dimerocrinus . .	—	2		
Echinocrinus . .	—	1		
Edriocrinus . .	1			
Enallocrinus . .	—	2		
Eugeniacrinus . .	—	1		
Glyptocrinus . .	15	4		
Grammocrinus . .	—	2		
Haplocrinus . .	—	2		
Heliocrinites . .	—	3		
Heterocrinus . .	9	1		
Homocrinus . .	7	1		
Hybocrinus . .	3			
Hypanthocrinus .	19	5	—	1
Ichthyocrinus .	3	1	—	1
Lampterocrinus . .	2			
Lecanocrinus . .	7			
Lepocrinus . .	1			
Lyriocrinus . .	2			
Macrostylocrinus .	2			
Mariacrinus . .	7	3	—	2
Marsupiocrinus . .	1	1	—	1
Megistocrinus .	3			
Melocrinites . .	3	2		
Myelodactylus .	3			
Nucleocrinus . .	1			
Pachyocrinus .	1			
Palæocrinus . .	4			
Pentremites . .	1			
Periechocrinus . .	—	3		
Phialocrinus . .	—	1		
Pisocrinus . . .	—	2		
Platycrinus . .	6	4		
Porocrinus . .	3			
Poteriocrinus . .	3	3		
Protocrinus . .	—	4		
Reteocrinus . .	2			
Rhodocrinus . .	5	3		
Sacoocrinus . .	1			
Sagenocrinus . .	1			
Schizocrinus . .	3			
Scyphocrinus . .	1	2		
Sphenocrinus . .	—	1		
Stephanocrinus . .	2			
Synbathocrinus .	1			
Syringocrinus . .	1			
Taxocrinus . .	1	4	—	1
Tetramerocrinus .	—	1		

	America.	Europe.	Other Countries.	Common.
Crinoidea—continued.				
Thysanocrinus .	6			
Trochocrinus . .		2		
	193	93	2	6
Cystidea.				
Amygdalocystites .	3			
Anomalocystites .	1			
Apiocystites . .	9	2	—	1
Ateleocystites . .	1	1		
Callocystites . .	2			
Caryocystites . .	1	4		
Comarocystites .	3			
Crinocystites . .	2			
Cryptocrinites .	—	2		
Cyclocystoides . .	3	2	—	1
Echinocystites .	—	3		
Echino-encrinus .	3	8	—	1
Echinosphærites .	—	12		
Glyptocystites .	4	1		
Glyptosphærites .	—	1		
Gomphocystites .	3			
Hemicosmites .	2	7		
Hemicystites . .	1			
Heterocystites .	1			
Holocystites . .	7			
Lepadocrinus . .	1			
Malocystites . .	2			
Palæocystites . .	4			
Pleurocystites . .	6	2		
Protocystites . .	—	1		
Prunocystites . .	—	1		
Pseudocrinites .	—	5		
Sphærocystites . .	1			
Sphæronites . .	—	7		
Sycocystites . .	—	2		
Trochocystites .	—	1		
	60	63	—	3
Asteroidea.				
Agelacrinites . .	3	1	—	1
Bothriocidaris .	—	2		
Edrioaster . . .	1	1		
Glyptaster . .	4			
Lepidaster . . .	—	2		
Palæaster . .	4	9		
Palæchinus . .	—	1		
Palæocoma . .	2	5		
Palæodiscus . .	—	2		
Palasterina . .	5	3		
Petraster . . .	4			
Protaster . .	1	4		
Stenaster . . .	3			
Tæniaster . .	2			
	29	29	—	1
Annelida.				
Aphrodita . . .	—	1		
Arenicolites . .	1	3	—	1
Boliviana . . .	3			
Campylites . .	—	2		
Chondrites . .	—	8		
Cornulites . .	4	1	—	1
Crossopodia . .	—	2		
Cruziana . .	4	13	—	2
Disophonus . .	—	1		
Forallites . .	—	2		
Fucoides . . .	2	3		
Haughtonia . .	—	1		
Helmintholites . .	—	1		
Histioderma . .	—	1		
Humilis . . .	—	5		
Lumbricaria . .	—	2		
Myrianites . .	—	2		
Nemertites . .	—	1		
Nereites . . .	1	6		
Phytopsis . .	2			
Platysolenites . .	—	1		
Psephidium . .	—	1		
Pyrotenema . .	—	1		
Scolecoderma . .	—	2		
Scolicolithus . .	—	1		
Scolithus . .	3	4	—	1
Serpula . . .	—	2	1	
Serpulites . . .	3	7		

	America.	Europe.	Other Countries.	Common.
Annelida—continued.				
Spirorbis	1	3		
Tentaculites	15	17	—	2
Trachyderma	—	5		
Vermiculites	—	1		
	39	100	1	7
Crustacea.				
Trilobita.				
Acanthopyge	—	1		
Acerocare	—	1		
Acidaspis	11	67		
Acontheus	—	1		
Actinopeltis	—	1		
Æglina	—	18		
Aglaspis	3			
Agnostus	15	52		
Amphion	9	13		
Ampyx	9	31		
Angelina	—	2		
Anomocare	—	6		
Anopocare	—	1		
Anopolenus	—	2		
Arethusina	—	2		
Areia	—	2		
Arges	1			
Arionellus	9	3		
Arraphus	—	1		
Asaphus	35	80		
Atops	2			
Barrandia	—	5		
Basilicus	—	9		
Bathyonotus	1			
Bathyurellus	9			
Bathyurus	38			
Bohemilla	—	1		
Brachyaspis	—	1		
Bronteopsis	—	1		
Bronteus	8	62		
Bumastus	9	9		
Calymene	31	86		
Carmon	—	2		
Celmus	—	1		
Centropleura	—	3		
Chariocephalus	1			
Cheirurus	34	76		
Conocoryphe	36	27		
Corynexochus	—	2		
Crepicocephalus	4			
Cromus	1	5		
Crotalurus	—	1		
Cybele	1	24		
Cyphaspis	1	22		
Cyphoniscus	—	1		
Cyrtometopus	—	11		
Dalmania	26	50		
Deiphon	—	6		
Dikelocephalus	31	4		
Dindymene	—	4		
Dionide	1	3		
Dolichometopus	4	1		
Dysplanus	—	9		
Ellipsocephalus	1	5		
Encrinurus	13	24		
Endymionia	2	1		
Erinnys	—	1		
Eryx	—	1		
Euloma	—	3		
Eurycare	—	5		
Harpes	8	25		
Harpides	5	4		
Holocephalina	—	3		
Holometopus	2	3		
Homalonotus	11	38		
Homalopteon	—	4		
Hydrocephalus	—	2		
Illænopsis	—	1		
Illænurus	1			
Illænus	51	96		
Isocolus	—	1		
Isotelus	17	5		
Leptoplastus	—	3		
Lichas	19	85		
Liostracus	—	3		
Loganellus	1			
Lonchocephalus	4			
Lonchodomus	—	8		
Megalaspis	—	23		
Menocephalus	4			

	America.	Europe.	Other Countries.	Common.
Trilobita—continued.				
Microdiscus	1	1		
Nileus	4	7		
Niobe	—	9		
Octoillænus	—	1		
Ogygia	—	25		
Ogygiocaris	—	1		
Olenellus	4			
Olenus	4	32		
Palæopyge	—	1		
Panderia	—	3		
Parabolina	—	2		
Paradoxides	10	22		
Pemphigaspis	1			
Phacops	29	129		
Pharostoma	—	6		
Placoparia	—	6		
Platymetopus	—	2		
Plesiocoma	—	4		
Polyeres	—	2		
Polytomurus	—	2		
Proetus	10	65		
Prosopiscus	—	1		
Psilocephalus	—	2		
Ptychaspis	7			
Ptychopyge	—	15		
Raphiophorus	—	6		
Remopleurides	3	19		
Rhodope	—	5		
Salteria	—	2		
Sao	—	2		
Shumardia	2			
Solenopleura	—	4		
Sphærexochus	6	30		
Sphærocoryphe	1	3		
Sphærophthalmus	—	11		
Staurocephalus	—	9		
Stygina	—	4		
Symphysurus	—	3		
Telephus	1	4		
Tiresias	—	1		
Trapelocera	—	6		
Triarthrellus	1			
Triarthrus	10			
Trilobites	—	23		
Trinucleus	7	67		
Zethus	—	3		
	570	1600		

The total number of species is 1639; about 20 species from India and Australia are included in the European list.

Ostracoda.				
Phyllopoda.				
Astacoderma	—	14		
Bairdia	—	1		
Beyrichia	24	22	1	3
Bunodes	—	3		
Caryocaris	—	1	1	
Ceratiocaris	6	14		
Climatichnites	1			
Cythere	2	2		
Cytherina	4	6		
Cytheropsis	3			
Dictyocaris	—	3		
Discinocaris	—	1		
Dithyrocaris	—	2		
Entomis	—	1		
Eurypterus	7	15	—	1
Exapinurus	—	1		
Hemiaspis	—	5		
Himantopterus	—	5		
Hymenocaris	—	1		
Leperditia	14	31	—	1
Limuloides	—	3		
Lingulocaris	—	1		
Myocaris	—	3		
Parka	—	1		
Peltocaris	—	2		
Primitia	5	26		
Protichnites	6	1		
Pseudoniscus	—	1		
Pterygotus	3	7		
Særichnites	1			
Slimonia	—	3		

	America.	Europe.	Other Countries.	Common.
Phyllopoda—continued.				
Stylonurus	—	1		
Turrilepas	—	1		
	76	178	2	5
OLLUSCA.				
Polyzoa.				
Alecto	1			
Archæopora	—	5		
Arthroclema	1			
Berenicea	—	2		
Cellepora	—	1		
Ceramopora	3	1		
Ceriopora	—	6		
Chasmatopora	—	1		
Cladopora	1	5	—	1
Clathropora	5			
Coccoseris	—	2		
Diamesopora	1			
Diastopora	—	2		
Diplastrea	—	1		
Diplophyllum	1			
Discopora	—	3		
Disteichia	—	1		
Eschara	—	1		
Escharina	—	1		
Fenestella	12	17	—	3
Glauconome	—	1		
Graptolithus	22	32	3	2
Buthograptus	1			
Callograptus	2			
Cladograpsus	—	2		
Climacograptus	4			
Coronoides	—	4		
Dendrograptus	8	1		
Dichograptus	17	2	3	3
Dictyonema	9	5		
Didymograpsus	6	8	5	4
Diplograpsus	18	19	7	4
Phyllograptus	5	2	2	2
Ptilograptus	2			
Rastrites	—	4		
Retiolites	5	4	—	1
Tetragrapsus	1	2		
Helopora	13			
Heteropora	—	3		
Hornera	1			
Inocaulis	1			
Intricaria	1	1		
Lichenalia	1			
Mastopora	—	1		
Micropora	—	3		
Phænopora	4			
Phyllopora	—	3		
Polypora	3	3		
Protovirgularia	—	1		
Pteropora	—	2		
Ptilodictya	28	19	2	4
Ptylopora	—	1		
Retepora	7	3		
Rhabdinopora	—	2		
Rhinopora	2			
Sagonella	1			
Synocladia	—	2		
Thamniscus	—	1		
Trematopora	14	1		
Urceopora	—	2		
Vincularia	—	2		
	201	185	22	24
Brachiopoda.				
Acrotreta	2	1		
Athyris	15	21		
Atrypa	67	21	3	5
Aulonotreta	—	2		
Camarium	2			
Camerella	15	1		
Chonetes	6	16		
Crania	1	10		
Cyrtia	2	2		
Discina	20	33	2	1
Eatonia	4			
Eichwaldia	2			
Leptæna	39	72	8	3
Leptocœlia	7	3		
Lingula	57	42	5	3
Lingulella	—	9		
Brachiopoda—continued.				
Lingulepis	2			
Lingulocaris	—	1		
Meganteris	4			
Merista	19	6	—	2
Meristella	9	8	—	1
Nucleospira	5			
Obolella	10	8	—	1
Obolus	9	10	—	2
Orthis	132	155	10	16
Orthisina	5	22	—	1
Pentamerus	18	36	1	6
Pholidops	2			
Platystrophia	—	6		
Porambonites	1	12		
Rensselæria	5			
Retzia	2	9	1	1
Rhynchonella	69	103	2	8
Rhynchospira	5			
Siphonotreta	—	4	2	1
Skenidium	3			
Spirifera	39	66	2	5
Spirigerina	—	4		
Strophodonta	12			
Strophomena	61	39	8	10
Trematis	8	5	—	2
Trematospira	11			
Trigonotreta	—	1		
Trimerella	2			
Triplesia	6 ?	2		
Tropidoleptus	1			
Zygospira	2			
	681	729	44	68
Lamellibranchiata.				
Dimyaria.				
Ambonychia	38	17		
Avicula	48	36	1	
Megambonia	14			
Posidonomya	1	3		
Pterinæa	19	51		
	120	107	1	

These figures represent appearances; the number of species is 155.

Monomyaria.				
Actinodonta	—	1		
Anatina (?)	2			
Anodontopsis	—	13		
Arca	1	10		
Astarte (?)	—	1		
Axinus	—	1		
Cardiola	—	24		
Cardiomorpha	—	5		
Cardita	—	1		
Cardium	—	8		
Cleidophorus	14	9	1	
Conocardium	8	14		
Ctenodonta	21	73	8	
Cucullella	1	13		
Cypricardia	9	14		
Cypricardinia	6			
Disteira	—	1		
Dolabra	1	3		
Edmondia	1			
Eopteria (?)	3			
Euchasma	1			
Goniophora	—	7		
Grammysia	2	16		
Hippomya	—	1		
Ischarinia	2			
Isocardia (?)	—	5		
Lucina	1	4		
Lunulacardium	—	6		
Lyrodesma	5	4		
Matheria	3			
Megalodon	—	2		
Modiolopsis	64	57		
Myalina	2			
Mytilus	1	12		
Orthonota	13	55	1	
Palæarca	46	11	14	
Psammobia	—	4	1	
Pseudaxinus	—	1		

	America.	Europe.	Other Countries.	Common.
Monomyaria—continued.				
Pyronomæus . .	2			
Redonia . .	—	11		
Ribeiria . . .	2	6		
Tellinites . .	—	1		
Tellinomya . .	21	—		
Vanuxemia . .	3	1		
	235	395	25	
Pteropoda.				
Bellerophon . .	29	50	2	7
Bucania . . .	16	—		
Coleoprion . .	—	2		
Conularia . .	10	24	—	2
Cyrtolites . . .	6	4	—	1
Cyrtotheca . .	6	8	1	
Ecculiomphalus .	8	3		
Lonchidium . .	—	3		
Maclurea . .	21	12	—	3
Pterotheca . .	2	5		
Salterella . .	3	1		
Stenotheca . .	—	1		
Theca . . .	5	34	2	2
	106	147	5	15
Gasteropoda.				
Acroculia . . .	53	75		
Calyptræa . .	—	2		
Carinaropsis . .	6			
Cerithium . .	—	2		
Chemnitzia (?) . .	—	—	1	
Chiton . . .	1	2		
Cirrus . . .	—	7		
Cleodora . .	1	2		
Clioderma . . .	6			
Clisiospira . .	2			
Cyclonema . .	31	24	2	
Delphinula (?) .	—	7		
Dentalium . .	—	4		
Eunema . . .	8	2	1	
Euomphalus . .	13	103	1	
Gyrotrema . .	—	5		
Helicotoma . .	19	1	2	
Holopea . . .	21	15	3	
Holopella . . .	—	20	1	
Hormotoma . .	—	—	2	
Littorina . . .	—	2		
Loxonema . .	20	11	1	
Macrocheilus . .	2	2		
Metoptoma . .	26	3		
Murchisonia . .	127	66	5	
Natica . . .	1	26		
Naticella . . .	—	5		
Ophileta . .	19	4		
Patella . . .	1	10		
Phasianella . .	—	2		
Pilidion . . .	—	6		
Platychisma . .	2	8		
Platyostoma . .	15			
Pleurotomaria .	152	80	4	
Porcellia . . .	3	5		
Raphistoma . .	18	21	2	
Rotella . . .	—	6		
Scalites . . .	2	1	1	
Scoliostoma . .	—	1		
Siphonaria . .	—	1		
Stomatella . .	—	1		
Straparollina . .	1			
Straparollus . .	8			
Strophostylus . .	6			
Subulites . . .	19	10		
Trochonema . .	8	7	2	
Trochus . . .	—	23		
Tubina . . .	—	7		
Turbo . . .	5	43	1	
Turritella . .	—	12		
Vermetus . . .	—	2		
	596	636	29	

These figures represent appearances; the species number 994 in all.

	America.	Europe.	Other Countries.	Common.
Cephalopoda.				
Actinoceras . .	27	8	1	
Ascoceras . . .	4	15		
Aphragmatites .	—	2		
Glossoceras . .	—	2		
Bactrites . .	1	2		
Bathmoceras . .	—	2		
Cameroceras . .	1	1		
Clymenia . . .	—	6		
Cochlioceras . .	—	2		
Cycloceras . .	—	18		
Cyrtoceras . .	60	291	2	
Cyrtocerina . .	2			
Dictyoceras . .	—	1		
Discosurus . .	3			
Endoceras . .	30	14		
Gomphoceras . .	5	78		
Goniatites . .	—	17		
Gonioceras . .	7			
Gyroceras . .	2	8		
Heloceras . . .	—	1		
Hemiceras . .	—	3		
Hercoceras . .	—	2		
Lituites . . .	19	42	2	
Nautilus . . .	11	9	1	
Nothoceras . .	—	2		
Oncoceras . . .	19	2		
Orthoceras . .	229	657	10	
Phragmoceras . .	5	25		
Piloceras . .	7	2		
Streptoceras . .	2			
Trematoceras . .	—	1		
Tretoceras . . .	—	2		
Trochoceras . .	2	48		
Trocholites . .	3	6		
	439	1269	16	

The figures for the above class indicate appearances; the number of species is 1419.

VERTEBRATA.				
Pisces.				
Asterolepis . .	—	1		
Auchenaspis . .	—	1		
Cephalaspis . .	—	6		
Coccosteus . .	—	2		
Ctenacanthus . .	—	2		
Dendrodus . . .	—	1		
Dipterus . .	—	1		
Glyptolepis . .	—	1		
Gompholepis . .	—	1		
Leptocephalus . .	—	3		
Macropetalichthys .	—	1		
Odontolodus . .	—	1		
Onchus . . .	—	2		
Plectrodus . .	—	2		
Pteraspis . .	—	4		
Sclerodus . . .	—	2		
Sphagodus . .	—	1		
Thelodus . . .	—	1		
Tollipeltis . .	—	1		
		34		

In order to test how far these lists indicate geographical regions, we will analyze one group, viz., the *Actinozoa*. This, however, can only be done in a rough way, relying mainly upon some tables drawn up from Dr. Bigsby's work, which indicate the geographical distribution of the species during the lower, middle, and upper Silurian periods. From these tables, which would be far too lengthy to insert here, we at once perceive that by far the larger proportion of the fossils have been collected from the east side of North America, between 35° and 60° N. lat., and from Europe between 45° and 70° N. lat. The whole of both areas comprises only a small portion of that which was covered by the Silurian seas, so that as yet we cannot expect to obtain much insight into the geographical areas of this period, if there were any. Only eight species are known from other localities than above indicated, a number quite insufficient to place much reliance on for indications as to general conclusions. In America the species of the lower Silurian period have been obtained for the most part along a broad band from Tennessee and Missouri on the S.W., to Anticosti Island and Nova Scotia on the N.E. The Tennessee species are eight in number, viz.:—

Streptelasma profundum.
Columnaria Blainvilli.
C. stellata.
Chætetes columnaris.
C. lycoperdon.
C. petropolitana.
Favistella alveolata.
F. stellata.

They represent the families *Cyathophyllidæ*, *Theciidæ* and *Favositidæ*. One species, *Columnaria stellata*, is known from Tennessee only; another, *Chætetes columnaris*, ranges into New York; *Streptelasma profundum* occurs in Michigan, New York, and Canada. *Favistella alveolata* ranges into Canada and the Hudson Bay Territory; *Columnaria Blainvilli* has nearly the same range as the last species; *Chætetes lycoperdon* spreads over a somewhat larger area, occurring in Missouri on the west, in Michigan and Canada on the north, and in Virginia and New York on the east. *Chætetes petropolitana* has a wider range than any occurring in Kentucky, Ohio, Canada, Norway, Sweden, Ireland, Wales, Prussia, and Russia.

In New York the lower Silurian species are 22 in number, viz.:—

Streptelasma crassum.
S. expansum.
S. multilamellatum.
S. parvulum.
S. profundum.
Stauria astræaformis.
Columnaria Blainvilli.
C. sulcata.
Halysites catenulatus.
Chætetes lycoperdon.
C. columnaris.
C. two sp. undet.
Constellaria antheloidea.
Favosites Hisingeri.
Heliolites vetusta.
Protarea vetusta.
Discophyllum peltatum.
Favistella stellata.
Stenopora fibrosa, var. lycoperdon.
Stellipora antheloidea.
Diplophyllum sp.

In this list there are representatives of the families *Cyathophyllidæ*, *Stauriidæ*, *Theciidæ*, *Favositidæ*, and *Poritidæ*. The species not known beyond the state are *Streptelasma crassum*, *S. expansum*, *S. multilamellatum*, *S. parvulum*, *Stauria astræaformis*, *Chætetes*, two undetermined species, *Heliolites vetusta*, and *Discophyllum peltatum*, or nine in all. *Chætetes rugosa* and *Diplophyllum sp.* range to Ohio; *Constellaria antheloidea* to Indiana; *Stellipora antheloidea* to the Upper Mississippi; *Columnaria sulcata* to Canada; *C. Blainvilli* and *Favistella stellata* to Tennessee and Canada; *Chætetes lycoperdon* to Missouri and Canada; *Favosites Hisingeri* to Pennsylvania on the one hand and the Hudson Bay Territory on the other; *Protarea vetusta* and *Streptelasma profundum* to Indiana, Michigan, and Canada; *Stenopora fibrosa* var. *lycoperdon* to Wales and Westmoreland; and *Halysites catenulatus* to Canada, the British Isles, and Russia.

In Canada 50 species have been recorded, viz.:—

Streptelasma profundum.
Zaphrentis affinis.
Z. bellistriata.
Z. bilateralis.
Z. canadensis.
Columnaria alveolata.
C. Blainvilli.
C. erratica.
C. incerta.
C. Goldfussi.
C. parva.
C. rigida.
C. sulcata.
Halysites catenulatus.
Chætetes lycoperdon.
C. petropolitana.
Dania huronense.
Labechia dendrosa.
Favosites fibrosa.
F. prolificus.
F. Hisingeri.
F. favosa.
Heliolites megastoma.
Propora tubulata.
Protarea vetusta.
Bolboporites americana.
Calopœcia canadensis.
C. huronensis.
Favistella alveolata.
F. stellata.
F. favosa.
Nebulipora dendrosa.
N. petropolitana.
Palæophyllum rugosum.
Petraia aperta.
P. corniculum.
P. angulata.
P. ottowaensis.
P. profunda.
P. rustica.
P. sulcata.
Stenopora adhærens.
S. huronensis.
S. concava.
S. fibrosa.
S. f. var. lycoperdon.
S. globosa.
S. mammillata.
S. patula.
S. petropolitana.
S. papillata.

The families represented are *Cyathophyllidæ*, *Theciidæ*, *Favositidæ*, and *Poritidæ*.

The Welsh species are 25 in number, and are named as follows:—

Cyathophyllum turbinatum.
Omphyma turbinatum.
Thecia petaliformis.
Halysites catenulatus.
H. polymorpha.
Chætetes petropolitana.
Favosites aspera.
F. alveolaris.
F. gothlandica.
F. multipora.
Heliolites megastoma.
H. tubulatus.
H. petaliformis.
H. interstinctus.
H. inordinatus.
Favistella alveolaris.
Nebulipora explanata.
N. favulosa.
N. f., var. lens.
Petraia æquisulcata.
P. uniserialis.
P. u., var. gracilis.
P. rugosa.
P. subduplicata, var. crenulatus.
P. elongata.
Stenopora fibrosa.
S. f., var. lycoperdon.
S. regularis.

These belong for the most part to the same families as the American species. Comparing it with the Canadian list, it appears that there are 18 genera in Canada, and 11 in Wales; that 8 of the genera have representatives in both areas; so that there are 10 Canadian genera which do not occur in Wales, and 3 Welsh genera which have not been recorded in Canada. The number of species common to Canada and Wales is 4.

The Russian species number 45; viz.:—

Cystiphyllum excavatum.
C. obliquum.
Cyathophyllum flexuosum.
Omphyma subturbinatum.
Zaphrentis dilatata.
Halysites approximata.
H. catenulatus.
Thecia confluens.
Cœnites laciniatus.
Chætetes petropolitana.
C. heterosolen.
C. Panderi.
Favosites polymorpha.
F. alveolaris.
F. patellaria.
F. reticulata.
Alveolites annulatus.
A. apiculatus.
A. hemisphæricus.
A. pyriformis.
A. repens.
Heliolites interstinctus.
H. macrostylus.
H. megastoma.
Propora tubulata.

Palæocyclus Fletcheri.
P. mitreola.
Bolboporites mitralis.
B. semiglobosus.
B. stellifer.
B. triangularis.
B. uncinatus.
Dianulites detritus.
D. fastigiatus.
Myriolites fastigiatus.
Nebulipora ovulum.
Orbipora distincta.
O. fungiformis.
Astrocerium reticulatum.
Sarcinula organum.
Stenopora fibrosa.
Syringophyllum organon.
Syringopora intricata.
S. conglomerata.
S. dichotoma.

In this area there are 23 genera, of which eight are represented in Canada, and nine are represented in Wales. Of the species, five also occur in Canada, and six in Wales. Considering the position of the areas which we have been dealing with, the facts do not indicate so great a uniformity of the Silurian fauna as is usually supposed. The majority of the species have ranges quite as restricted as those of the present day; and even in the northern hemisphere the most of the genera do not range all round the globe. Some of the genera no doubt occur almost everywhere; but examples of a similar kind are not wanting amongst modern genera, although it is to be noticed the majority of living species flourish in low latitudes.

In the following table we have incorporated the list of Canadian, Welsh, and Russian species of the middle and upper Silurian periods; to which is added the upper Silurian forms of Staffordshire:—

	Mid-Silurian.			Upper Silurian.			
	Canada.	Wales.	Russia.	Canada.	Wales.	Russia.	Stafford-shire.
Acervularia ananas	—	—	—	—	—	—	●
A. antiqua	—	—	—	—	—	●	
A. luxurians	—	—	—	—	—	—	●
Alveolites Grayi	—	—	—	—	—	—	●
A. Labechei	●	●	—	—	●	●	●
A. repens	—	●	—	●	—	—	●
A. serrato-poroides	—	—	—	—	—	—	●
Amplexus cingulatus	●						
A. laxatus	—	—	—	●			
Arachnophyllum typus	—	—	—	—	—	—	●
Astrocerium mitratum	—	—	—	—	—	—	●
A. reticulatum	—	—	—	—	—	●	
Campophyllum flexuosum . . .	—	—	—	—	—	●	
Calopœcia anticostensis . . .	●						
Callopora sp.	—	—	—	●			
Chætetes alveolaris	—	—	—	●			
C. Bowerbankii	—	—	—	—	—	—	●
C. columnaris.	—	—	—	●			
C. Fletcheri	—	—	—	—	—	—	●
C. hemisphærica	—	—	—	—	—	●	
C. pulchella	—	—	—	—	—	—	●
Chonophyllum Belli	●						
Cladopora cæspitosum	—	—	—	●			
C. multipora	—	—	—	●			
C. seriata	—	—	—	●			
Clathropora frondosa	—	—	—	●			
Clisiophyllum buceros	—	—	—	—	—	●	
C. cristatum	—	—	—	—	—	●	
C. eminens	—	—	—	—	—	●	
C. Hisingeri	—	—	—	—	—	●	
Cœnites clathrata	—	—	—	—	—	—	●
C. fructuosa	—	—	—	—	●		
C. intertextus	—	—	—	—	●	●	●
C. juniperinus	—	●	—	—	●	●	●
C. labrosus	—	—	—	—	—	—	●
C. laminata	●						
C. linearis	—	—	—	—	—	●	●
C. nodulosus	—	—	—	—	—	●	
C. strigatus	—	—	—	—	—	—	●
Columnaria Blainvilli	●						
C. galtensis	—	—	—	●			
C. sulcata	—	—	—	—	—	●	
Cyathophyllum anticostiense . .	●						
C. articulatum	—	—	—	—	—	●	●
C. coralligerum	—	—	—	—	—	●	
C. Eriphyle	●						
Cyathophyllum Euryone . . .	●						
C. flexuosum	—	—	—	—	—	●	
C. interuptum	●						
C. Loveni	—	—	—	—	—	—	●
C. nymphale	●						
C. Pasithea	●						
C. Pennanti	●						
C. pelagicum	●						
C. pileolus	—	—	—	—	—	●	
C. recurvum	—	—	—	—	—	—	●
C. Shumardi	—	—	—	●			
C. solitarium	●						
C. turbinatum	—	—	—	—	—	—	●
C. truncatum	—	—	—	—	—	●	●
C. Wahlenbergii	●						
Cylindripora serpuloides. . .	—	—	—	—	—	●	
C. tubus	—	—	—	—	—	●	
Cystiphyllum cylindricum . .	—	—	—	—	—	●	●
C. excavatum	—	—	—	—	—	●	
C. huronense	●	—	—	●			
C. impunctum	—	—	●				
C. maritimum	●						
C. siluriense	—	—	—	—	—	—	●
Diplophyllum flexuosum . .	—	—	—	—	—	—	●
D. irregularis	—	—	—	●			
Eridophyllum Vennori	●						
Favistella alveolaris	—	●					
Favosites alveolaris	—	●	●	—	●	●	
F. a. var. multipora	—	●	—	—	●		
F. aspera	—	—	●	—	—	—	●
F. capax	●						
F. constricta	—	—	—	●			
F. cristata	—	—	—	—	—	●	●
F. favosa	●	—	—	●	—	●	
F. Forbesii	—	—	—	—	—	●	●
F. gothlandica	●	—	●	●	—	●	●
F. Hisingeri	●	—	—	—	—	●	
F. lycoperdon	●						
F. multipora	—	●	●	—	●	●	
F. polymorpha	—	—	●	●	—	—	●
F. prolificus	●						
F. ramosa	—	—	—	—	—	●	
F. reticulata	—	—	—	—	—	●	
Goniophyllum Fletcheri . . .	—	—	—	—	—	—	●
G. pyramidale	—	—	—	—	●		
Halysites catenulatus	—	—	●	●	●	●	
H. communicans	—	—	●				
H. exilis	—	—	●				
H. labyrinthica	—	●	—	—	—	—	●
Heliolites elegans	—	—	—	●			
H. favosus	—	—	●				
H. interstinctus	●	●	—	●			
H. megastoma	—	●	●	●	—	—	●
H. microporus	—	—	—	—	—	●	
H. Murchisoni	—	—	—	—	—	—	●
H. petaliformis	—	●	—	—	—	—	●
H. porosus	—	—	—	—	—	●	
H. pyriformis	—	—	—	—	●	—	●
H. sparsus	●						
H. speciosus	●						
H. spinipora	—	—	—	●			
H. tenuis	●						
H. tubulatus	—	●	—	—	—	—	●
Helopora armata	●						
H. bellula	●						
H. Circe	●						
H. concava	●						
H. fragilis	●						
H. formosa	●						
H. irregularis	●						
H. lineata	●						
H. lineopora	●						
H. nodosa	●						
H. striatopora.	●						
H. strigosa.	●						
H. varipora	●						
Labechia conferta	—	—	—	—	—	●	
L. radula	—	—	—	—	—	●	
L. Sternbergii	—	—	●				
Laceripora cribrosa	—	—	—	—	—	●	
Lithostrotion antiquum . . .	—	—	—	—	—	●	
Lonsdalia wenlockensis . . .	—	—	—	—	—	—	●
Lyellia americana	●						
Millepora repens	—	—	—	—	—	—	●
Nebulipora ovulum	—	—	●				
N. papillata	—	—	—	—	—	—	●
Omphyma canina	—	—	—	—	—	—	●

	Mid-Silurian.			Upper Silurian.			
	Canada.	Wales.	Russia.	Canada.	Wales.	Russia.	Stafford-shire.
Omphyma congregata	*	—	—	*			
O. discus	—	—	—	—	—	*	
O. Drummondi	*	—	—	*			
O. fastigiatum	—	—	*				
O. Murchisoni	—	—	—	—	—	—	*
O. septigerum	—	—	*				
O. subturbinatum	—	—	—	—	—	*	
O. turbinatum	—	*	—	—	*	—	*
O. verrucosa	—	—	—	*			
Pachyphyllum gibberosum	—	—	—	—	—	*	
Palæocyclus Fletcheri	—	—	—	—	—	*	*
P. porpita	—	—	—	—	—	—	*
P. præacutus	—	*	—	—	—	—	*
P. rugosus	—	—	—	—	—	*	*
Petraia bina	—	—	—	—	*		
P. calicula	—	—	—	*	—	—	*
P. elongata	—	*					
P. latuscula	*						
P. pulchella	*						
P. pygmæa	*						
P. reticulata	—	*					
P. rugosa	—	*					
P. selecta	—	*					
P. subduplicata	—	*	—	—	*		
P. s., var. crenulata	—	*					
P. uniserialis	—	*					
P. u., var. gracilis	—	*					
Plasmopora petaliformis	—	—	—	*	—	—	*
P. scita	—	—	—	—	—	—	*
Propora conferta	—	—	—	—	—	*	
P. tubulata	*	—	—	—	—	—	*
Ptychophyllum canadense	*						
P. patellatum	—	—	—	—	—	—	*
P. Stokesii	—	—	—	*			
Sarcinula organum	—	—	—	—	—	*	*
Stauria astræaformis	—	—	—	—	—	*	
Stenopora bulbosa	*						
S. fibrosa	—	*	*	*	*	*	*
S. f., var. incrustans	—	—	—	—	*		
S. f., var. ramulosa	—	—	—	—	*	—	*
Strephodes pseudoceratites	—	—	—	—	*	—	*
S. trochiformis	—	—	—	—	—	—	*
S. sp.	—	*					
Striatopora flexuosa	—	—	—	*			
Strombodes diffluens	*						
S. eximius	*	—	—	*			
S. gracilis	—	—	—	*			
S. Labechei	—	—	—	—	—	—	*
S. Murchisoni	—	—	—	—	—	—	*
S. pentagonus	—	—	—	*			
S. striatus	—	—	—	*			
S. wenlockensis	—	—	—	—	—	*	*
Syringophyllum organon	—	—	—	—	—	—	*
Syringopora bifurcata	—	*	—	—	—	*	*
S. cæspitosa	—	—	—	—	—	—	*
S. cancellata	—	*	*				
S. compacta	—	—	—	*			
S. conglomerata	—	—	—	—	—	—	*
S. Dalmanni	—	—	—	*			
S. elegans	—	—	—	—	—	*	
S. fascicularis	—	—	—	—	*	*	*
S. intricata	—	—	*	—	—	*	
S. Lyelli	—	—	—	*			
S. repens	—	—	—	—	—	*	
S. retiformis	—	—	—	*			
S. serpens	—	*	—	—	*	—	*
S. serpuloides	—	—	—	—	—	*	
S. tenuissima	—	—	—	—	—	*	
S. tubus	—	—	—	—	—	*	
S. verticillata	—	—	—	*			
S. sp.	—	—	—	*			
S. sp.	—	—	—	—	*		
Thecia approximata	—	—	—	—	—	*	
T. cauliculus	—	—	*				
T. expatiata	—	—	—	—	—	—	*
T. Swindernana	—	—	—	—	—	—	*
Zaphrentis affinis	*						
Z. bellistriata	*						
Z. Bigsbyi	*	—	—	*			
Z. bilateralis	*						
Z. cinctosa	*						
Z. denticulata	—	—	—	*			
Z. Marcoui	*						
Z. ornata	—	—	*				
Z. patens	*						
Z. Stokesi	—	—	—	*			
Z. tenuilamellata	—	—	—	—	—	*	
Z. turbinata	—	—	—	—	—	—	*

SINAPIS [E. C. vol. iv. col. 786]. The common charlock is named *Sinapis arvensis*, and is a common weed in Western Europe. In France the oil obtained from it is used for burning in lamps, and the leaves are frequently given to cattle. In this country, we believe, it is not utilised, although it might be rendered a serviceable plant by careful cultivation.

SPECIES. The first question which is suggested in thinking of this subject is, What is a species? This question has been variously answered by the most eminent students of living forms. The generally accepted definition is that all those individuals constitute a species which have descended genetically from one individual, or from two individuals, or from several pairs, which first parents presented amongst themselves differences of the same kind and amount as occur amongst their descendants. Such a definition is manifestly hypothetical, and, like all such definitions, its validity must be tested experimentally. The most important test is the physiological. According to it those groups are specifically identical which are fertile or self-perpetuative: while they are specifically different if their unions are sterile beyond a few generations. Another kind of test is based upon differences of structure and external characters, and is the one almost exclusively resorted to by zoologists, especially by those who are most celebrated as discoverers of new species. If one watches the biological literature as it issues, and studies the descriptions of thousands of new species which appear annually, he is forcibly struck with the general non-manifestation of the employment of general principles in the determination of species. So much seems to depend upon rules formed in the course of the individual's own investigation, that we strongly suspect that, were half a dozen naturalists, who had been in the habit of working independently, set to draw up descriptive lists of the species in half a dozen different collections of animals of the same class, not one-third of the descriptions of the species common to all would tally. If our opinions are correct, it is highly important to bear in mind that the species of books are very variable in value, not always strictly comparable with one another, and not equivalent with the species as defined by nature. This ambiguity is one of the weakest points in biological science, and detracts from the value of every list and table. The difference of value depends upon a multitude of circumstances far too numerous for specification here. There are errors of observation, and there are errors of judgment, but the latter are far more numerous than the former. Supposing there to be no error, and that the specific names are accepted as valid, our knowledge of the species may vary greatly in extent. Sometimes, and far too frequently, it consists of a single individual, or only of a portion of one, while in others, and such cases are very few, it relates to thousands of individuals which have been carefully observed for a greater or less portion of their lives, and have been minutely examined after their death.

In order to obtain as clear an idea as possible of the nature of species, it is necessary to follow out a series of systematic researches. The species, whatever definition be adopted for it, is unquestionably formed of several elements, of which the most important are cells, organs, individuals, and varieties; each of which ought to be subjected to investigation. The former two pertain more particularly to physiology, and will not be noticed here, but a reference may be made to CELLS, E. C. S., and PANGENESIS, E. C. S., for some particulars relating to the first-mentioned element. In the case of the individual it is requisite to trace it through all its modifications, to compare in what respects the modifications of individuals are identical or dissimilar, and to ascertain, first, what are the efficient causes which produce the differences, and, next, how far circumstances may be altered without inducing change in the organism. After attention has been given to the individuals, attempts should be made to arrange them into groups according to the extent of the community of characters. Such groups are called strains, breeds, races, varieties, and species; and thence we ascend to larger groups, such as genera, families, orders, &c.

In the case of the individual there are a few prominent features which may be noticed here. No individual is absolutely the same from birth to death. The rapidity, extent, and complexity of change varies, but as a rule all are greatest in the most specialized forms. Every individual commences as a very simple organism, and the changes follow one another in a definite order and are evolved gradually. We ought to give a precise definition of what we mean by gradually, but it is almost impracticable to do so, since this and other terms used to express the same thing are purely relative. We mean by it a continuous evolution, but the rate and line of evolution may differ. In the case of man there are few persons who would dispute the assertion that the development of the adult from the infant takes place gradually, step by step, and not *per saltum*, or a great leap. And yet if the development were traced out with great minuteness of detail by a being whose idea of time was referred to standards very much less than our own, there would be apparent sudden changes answering to what some observers would call cataclysmal. In the ovum there occur but a few kinds of cells, and if a human individual were to develope as slowly as species are supposed to do by some, the same objections would apply to the idea that an egg became a man as are raised against the evolution of species by descent with modification. In the individual we see entirely new kinds of cells and organs, of which not the slightest traces are to be detected in the ovum. There are no traces whatever of the digestive system, of the heart, of the complicated organ of vision, and many other parts, in the ovum; and yet we know that these parts appear in the individual by a gradual process of evolution.

When we compare individual with individual we observe that in those which are most nearly allied the changes vary to a certain extent, sometimes very slightly, that the main phenomena mainly depend upon the character of the parents, while the trifling divergencies are for the most part due to the conditions under which the individuals are living. As our inquiries extend we perceive that the progeny of a parent go through almost the same phases as it did, or in other words, that like begets like. This last phrase should not be understood in its absolute sense, but as implying that the parent begets young which resemble it in most points, not in all. The details in which the young differ from the parents belong to several categories. Thus some are peculiarities which did not appear in the parents, but in some antecedent progenitor; while others are induced by the circumstances of life, such as food, degree and kind of exercise, and a multitude of similar modifying influences. In all species the number of ova formed is immensely greater than the number of procreative individuals developed; and the same remark applies to the fertilised ova, the embryo, and the progeny. It would be impossible for all to live and thrive, and hence the proportion of germs which die before arriving at maturity is surprisingly large. As the few live while the most die, it is clear that the few which thrive must have some advantage over the others. This advantage is a greater fitness for the conditions to which it is subjected, and as the rate of possible increase is far greater than the actual rate of increase, each individual has what Darwin terms a struggle for existence, those which survive being the fittest to do so. The preservation of certain individuals and the destruction of others is termed Natural Selection, a term which has been objected to by many, but, as we conceive, with little reason. It is the result of the operation of several natural laws which have been framed by the Great Lawgiver, and if the term is spoken of as actually producing those results, the phrase must be accepted in the metaphorical sense, and not as implying that there is any deified agent called Natural Selection. The same use of phrases repeatedly occurs in the literature of the arts and sciences without any objection being made. For instance, certain iron ores are crushed to fine powder, the powder is made to slide down an incline beneath an electro-magnet; an electric current is passed through the iron bars, in which state they are able to pick out or select the particles of magnetic iron from the gangue with which it was associated. Who would suppose, that, when we say the magnet selects the magnetic iron compound, we mean it acts otherwise than in obedience to certain laws framed by the Deity?

So far we have enumerated the general principles which are acquiesced in by most naturalists, viz., that individuals undergo change, produce other individuals which more or less closely resemble themselves, that all which commence existence do not arrive at maturity, that the few are selected while the most are rejected, and that the fittest survive. Beyond this we come upon disputable ground. According to some, species are immutable, that is, the amount of variation which it presents is unalterable from the first to the last moment of the existence of the species. Others believe that the variation may increase. In the opinion of one set of thinkers the extent is very slight; in that of another set considerable, and in that of certain others almost indefinite. The investigation of the amount of variation admissible in a species is rendered exceedingly difficult owing partly to the inconclusive nature of many of the experiments which man is able to carry out, and partly to the obstruction caused by the received definition of species not being based upon actual observation. If it be assumed that two distinct species cannot produce fertile offspring, and an inquirer attempts to show the fallacy of the definition by actually forming fertile offspring from two groups of creatures with different specific names, he is at once met with the reply that his experiments demonstrate that the two groups really belong to the same species. If, however, it could be shown that the two groups are two distinct species, the received definitions would fall to the ground. The whole subject, then, is one of immense difficulty, and therefore, as well as on account of want of space, we refrain from entering into the many interesting questions which the subject suggests. When writing the article PALÆONTOLOGY, E. C. S., it was our intention to enter fully into the discussion of the variation of species, but this also must be dismissed with brief notice. Natural Selection itself has little or no influence in inducing variation: all it does is to select certain variations in preference to others. The slightest variation is generally sufficient, but it may happen that the variation selected is of considerable divergence and has arisen suddenly. Cases of this kind have been frequently recorded. One of the most remarkable is the black-shouldered peacock. The common peacock presents slight variations as compared with other domesticated animals, but several instances are on record of the appearance of a form which differs so greatly from the ordinary kind that a celebrated ornithologist declared it to be a distinct species. The circumstances under which it has always originated leave little doubt that it is really a variety of the common peacock. If so, it would be referred to by many as an excellent illustration of the occasional appearance of an individual which differs considerably, and is without intermediate links from its nearest allies. The case is unquestionably one not easy to solve; but it is possible that the black-shouldered peacock is a reversion to some long antecedent ancestor. Most of the illustrations of sudden change are certainly cases of reversion; but these cannot be looked upon as abrupt leaps in the evolution of the species, since the original form acquired its character gradually. In the case of many domestic breeds differences of considerable amount have been produced within the historic period, and in not a few cases within the last few centuries. For instance, a wild gooseberry weighs about 5 dwts., and is seldom much above this. In 1786 cultivated gooseberries were obtained weighing 10 dwts.; in 1817 26 dwts. 17 grains were recorded, and up to a recent period the maximum attained was 37 dwts. 7 grains. We could mention many other cases belonging both to domesticated and to wild species, indicating that so long as the conditions are uniform the variation is limited; but when the conditions are altered the range of variation is altered. At times species certainly change at a much greater rate than $\frac{1}{5000000}$th part annually; and probably the average rate in the living world is much greater than this.

Those who wish for detailed discussion on the questions connected with species should consult Darwin's work 'On the Origin of Species,' and the numerous papers written by him since 1858, but more particularly his latest work, entitled 'Animals and Plants under Domestication.' Lamarck was one of the best and earliest thinkers on the subject. His views were first published in 1801; more fully in 1809, in his 'Philosophie Zoologie;' and lastly in his 'Hist. Nat. des Animaux sans Vertebres,' tome i. Other writers on the subject are, Geoffroy St. Hilaire, Wells, Herbert, Grant, Matthew, Von Buch, Rafinesque, Haldeman, d'Halloy, Owen, Isidore Geoffroy St. Hilaire, Freke, Herbert Spencer, Naudin, Keyserling, Schaafhausen, Lecoq, Baden Powell, Wallace, Von Baer, Huxley, Hooker, Carpenter, Dana, Parsons, Phillips, Agassiz, Claparede, Pelzeln, Lyell, Bates, Murray, Fee, King, Kölliker, Blanford, Flourens, Walsh, Duke of Argyle, Faivre, Laugel, Quatrefages, and many more.

SPHENODON. A brief allusion to this remarkable genus occurs in the article DRACONINÆ, E. C. vol. ii. col. 388, where, however, it is mentioned under its synonym *Hatteria*. The genus is also alluded to under HYPERODAPEDON, E. C. S. *Rhynchocephalus* is another of the appellations which have been applied to it. The genus consists of but one species, which exists in New Zealand, and although it was at one time abundant, its numbers are being rapidly thinned. It was first introduced to the notice of the scientific world towards the end of the last century by Cook and Anderson, since which it has been occasionally spoken of. Dieffenbach describes the '*tuatera*,' as *Hatteria punctata* is called by the natives, as living on rocky islets, and frequenting holes in the sand or amongst the stones. Of late years it has become the favourite food of the pig, and as it is also eaten by man, it will probably soon be extinguished.

A live specimen was acquired by the Zoological Society in 1868.

The only species of *Sphenodon* known has usually been placed in the family *Agamidæ*, but it differs from it in so many important respects, and indeed from every other family, that Dr. Günther has recently proposed to form a new order to receive it. These peculiarities will be found detailed in Dr. Günther's paper cited below; but we may refer to a few of them here. The mode of articulation of the lower jaw is very remarkable, and has, we believe, been met with in no other lizard. In lizards the quadrate and pterygoid are united by a joint which allows of considerable vertical movement in the lower jaw, but in the *Sphenodon* they are immovably connected by a sutural union. The two rami of the lower jaw are not connected by bone at the symphysis, but this part is formed by a fibrous tissue which allows of the two rami being laterally separated and then approximated to a small degree. The lower jaw is so connected with the condyles that these can play in a depression, and permit of the lower jaw being worked backwards and forwards. In connection with this structure of the lower jaw is an extraordinary type of dentition, which is as yet unique in the living world, but has its prototype in the dentition of the *Rhynchosaurus* and *Hyperodapedon*. The teeth are anchylosed with the alveolar margin, and are hence of the acrodont kind. In the upper jaw the teeth are placed in two rows on each side, one on the margin of the palatine bone, and the other on the maxillary bone, the two being so closely contiguous that only a narrow groove is left between them. In the lower jaw there is one row only on each side. All the rows of teeth form good cutting and sawing machines. The lower rows of teeth fit into the two grooves of the upper jaw, and as the lower jaw can be worked backwards and forwards, and the two rami are approximated when the jaw shuts, it may be conjectured that the dentition must be admirably adapted for cutting and sawing.

The muscular system also has its peculiarities, and it would seem that the abdominal muscles are so developed as to materially assist the animal in worming its way through narrow passages, and the addition of imbricated ventral scales implies that the latter are used in some way to assist progression. The following remarks from Dr. Günther will indicate some of the points in which *Sphenodon* differs from other saurians, and the views which that authority holds as to the systematic position of the genus. The possession of amphicœlian vertebræ is shared by it and the *Geckotidæ*, but by no other recent saurian. The ribs have appendages precisely similar in position to the uncinate processes in birds, and portions of the ribs are modified into broad plates for the attachment of abdominal muscles. There is a system of abdominal ribs different from the floating ribs of crocodiles, and from the continuation of true ribs which occur in the chamæleon. The coracoid is not notched, the scapula has an acromial tuberosity, and the os ilium has a subvertical direction; all which features are striking deviations from the lacertian type. There is no pecten or falciform process in the optic lens; and there is no tympanic cavity. The cochlea is more developed than in other lizards, showing the commencement of the spiral turns. The heart, the organs of respiration and digestion, and most of the other systems conform more or less closely to the lacertian type. "There can be no doubt that *Hatteria* must be removed from the family of *Agamidæ*, and that it is the type of a distinct group; but the question is whether this group should be subordinated to the Saurians as a distinct family like the *Agamidæ*, *Iguanidæ*, &c., or whether the characters pointed out are deemed of sufficient importance to assign to it a more distant position from the other lizards. In a system founded upon external characters only, the former course would be taken, and a family *Hatteriidæ* would be placed near the *Agamidæ*, with which it agrees in the majority of its external characters. However, there is scarcely a systematist of the present day who does not pay more or less attention to anatomical characters in establishing the higher divisions. Thus Dr. Gray admits into the diagnosis of his section *Squamata* (lizards and ophidians) the articulation of the tympanic to the skull, and the paired copulatory organs as principal characters by which it is distinguished from the second section, *Cataphracta* (= tortoises and crocodilians + amphisbænians). The division proposed by Stannius into *Streptostylica* (= snakes and lizards + amphisbænians), and *Monimostylica* (tortoises + crocodilians), is founded essentially on the same characters as that of Gray. *Hatteria* would not enter any of the divisions defined in these two systems. Professor Owen refers the recent reptiles to four co-ordinate orders, *Chelonia*, *Lacertilia*, *Ophidia*, and *Crocodilia*. *Hatteria* would probably enter the second, inasmuch as the character of 'procœlian vertebræ' assigned to this order is the only one by which *Hatteria* would be excluded; but the Geckos, which are lacertilians in Professor Owen's system, also have amphicœlian vertebræ. In the *Crocodilia*, likewise, this is not considered an ordinal character, but is used for the distinction of the suborders. In these three systems the crocodiles are removed from the lizards into a distinct order or section, on the ground of osteological characters as well as on account of the higher organisation of the soft parts. Now, in *Hatteria* the modifications of the lacertian skeleton extend to the same parts as in the crocodiles (except the anterior ribs and thoracic sternum), although they are frequently of a different nature; and the repetition of lacertian characters in its soft organs is in some measure counterbalanced by the absence of copulatory organs. Therefore we cannot hesitate to claim for it a rank higher than that of a family. The presence of a double bar across the temporal region, the intimate and firm connection of the os quadratum with the skull and pterygoids, the erect ilium, and the uncinate processes of the ribs, are characters by which a tendency towards the crocodilians is manifested; but here the resemblance ceases, and the affinities of *Hatteria* with the lizard are far more numerous and of greater importance. I need only mention the structure of the heart, of the organs of respiration and digestion, the absence of a diaphragm and of peritoneal canals, the transverse anal cleft, the absence of an external ear, the free tongue, &c. Yet were we to associate it with the lizards in one group, the unity of this group would be entirely destroyed. I propose, therefore, the following modification of Stannius's division of recent *Reptilia*, adding a few of the characters which appear to be of special importance in the determination of the affinities of *Hatteria*."

I.—Squamata.

Anal cleft transverse; copulatory organs paired, if present; all the ribs single headed; sacral vertebræ two or none.

Order 1. *Ophidia*.—Quadrate bone articulated to the skull; brain capsule entirely osseous; rami of the mandible united by ligament; copulatory organs present.

Order 2. *Lacertilia*.—Quadrate bone articulated to the skull; parts of the ali- and orbito-sphenoid regions fibro-cartilaginous; rami of the mandible united by suture; temporal region without or with only one horizontal bar; copulatory organs present.

Order 3. *Rhynchocephalia*.—Quadrate bone suturally and immovably united with the skull and pterygoid; parts of the ali- and orbito-sphenoid regions fibro-cartilaginous; rami of the mandible united by a short fibrous ligament; temporal region with two horizontal bars; vertebræ amphicœlian; copulatory organs none.

II.—Loricata.

Order 4. *Crocodilia*.—Quadrate bone suturally united with the skull; parts of the ali- and orbito-sphenoid regions fibro-cartilaginous; rami of the mandible united by suture; choanæ formed by pterygoid and palatine bones.

III.—Cataphractæ.

Anal cleft longitudinal; copulatory organ simple; trunk ribs and sternum dilated, more or less completely united by suture.

Order 5. *Chelonia*.

(Günther, *Phil. Trans.* vol. clvii. pp. 595—630.)

SPONGIADÆ [E. C. vol. iv. col. 879—881]. During the past few years our knowledge of this group has been much extended by the researches of Bowerbank, Carter, Lieberkühn, and others; but even now the mystery with which these and other lowly-organised animals have been invested, is only beginning to be removed. Unable to perceive any organs adapted for carrying on such vital functions as nutrition, excretion, circulation, &c., the biologist has been undecided whether to rank them as vegetables or animals. Although most recent authorities unhesitatingly refer them to the animal kingdom, yet it should be mentioned that while evidence has been accumulating in support of this view, numerous facts tend to prove that their structure presents much that appears to be common to them and the lower orders of plants. The difficulty of tracing any law regulating their forms, the apparent want of any animal motion or functional activity, and the general apathy with which they have been regarded, have probably been the cause of the slow progress made in acquiring a knowledge of sponges.

The essential parts of a sponge consist of a skeleton of spiculæ, supporting and secreted by the animal soft parts. The spiculæ are arranged according to a method which is constant and characteristic of each genus. But whatever this method may be, there is always one, and generally two, series of canals traversing them; these canals are termed *interstitial*. A *dermal membrane* envelopes the whole exterior portion of the skeleton; and in this membrane are a number of minute *pores*. The food-bearing current is drawn in through these pores, enters a cavity just beneath the dermal membrane termed the *intermarginal cavity*, from whence it passes into the *incurrent system* of interstitial canals to the interior of the sponge. The water is next conducted to the *excurrent* system, and is finally expelled through the orifices termed *oscula*, which are readily distinguished from the pores, owing to their usually being raised on a prominence.

Such are, in general, the essential parts of a sponge; but in order to obtain a clearer idea of their nature and connection with each other, it will be necessary to enter into more minute details. The soft parts will first engage our attention, since they are, physiologically, far more important than the hard parts.

Every cavity in the interior of a sponge is lined by a thin layer of *sarcode*, a semitransparent jelly-like substance, which unquestionably plays an important part in animals [Sarcode, E. C. S.]. The sarcode of the sponge varies in colour, being in some cases white, in others grey; when immersed in spirits it acquires the consistency of animal liver. Its surface is generally roughened by obtuse elevations of various sizes. It does not appear to possess any sensation of touch, since minute parasitical annelids are frequently found crawling over it and biting pieces from it without causing any apparent inconvenience to the sponge. No trace of structure can be seen in the ectosarc, even when examined with high microscopic powers, and yet it appears to be the seat of the locomotive power in the *Amœba*, and allied organisms. In some sponges, also, it possesses powers of motion, and when portions of it are detached they slowly and continuously change their form, and progress very much like an *Amœba*, as in *fig.* 32. Observations to this effect have been made by Carter, Bowerbank, Lieberkühn, and others, but the motive power does not appear to exist in all the species, nor yet all through the year. In *Spongilla* and *Hymeniacidon*, it is best seen in spring. Generally, the motion is due to a kind of contractile power, but in *Spongilla*, according to Lieberkühn, it is sometimes effected by cilia. Dr. Bowerbank examined a number of specimens of *Spongilla*, but the movements could be observed in some, and not in others. He failed to detect them in any of the marine species, and concludes that the power of motion is not a constant property of sarcode. The inner portion of the sarcode contains numerous granules, and is the place where the food is digested.

As far as observation has gone, it would seem that the thin layer of sarcode is rather to be regarded as an aggregation of amœboid bodies than as a continuous sheet. We have seen how readily they can be detached, but they can also be detected in the sponge itself when examined with the microscope. Thus Lieberkühn has noticed them in *Spongilla;* he states they are not amorphous, but possess distinct structures having the form of a cell, but without any membrane. When excrescent, a nucleus and nucleolus could be seen, but no *contractile vesicle*. In certain places these cells bear cilia; but these will be noticed presently. When the sarcode is examined by transmitted light, with a magnifying power of 400 or 500 linear, it is seen to be crowded with molecules of animal and vegetable matter in a more or less collapsed condition, and evidently undergoing digestion (*fig.* 1). Precisely the same phenomenon is presented by the mucous lining of the stomachs of higher animals. Now, although it would be impracticable to follow a particle of food from its entrance into the sponge to its exit again, we can infer what that course is. By referring to Amœba, E. C. S., the way in which that creature feeds will be seen. A cluster of such beings form the lining to the sponge cavities, and over their surface flows a powerful stream of water, bearing swarms of animalculæ; when these impinge against the sarcode they adhere, become embedded, digested, expelled again, and are carried on by the flowing water to the place of exit. When it is considered what a complicated system of canals a sponge possesses, it is clear that their aggregate length must be very great, and a proportionate supply of food will be required. That a sponge consumes a large quantity in proportion to its bulk, will strike any one who compares the afferent and efferent currents. The former may be laden with minute particles of matter, but the latter will contain a very small number of effete particles. By watching constantly it will be found that the inhalation proceeds with vigour for a time, and then subsides into comparative quiescence, and that the exhalent current continues to deliver effete particles with such remarkable uniformity as to indicate that they are thrown off from the sarcodous surface gradually and systematically.

Each of these currents of exhalation and inhalation have their special orifices, and can be seen best in *Halichondria incrustans* and *Spongilla fluviatilis*. But they can be seen in almost any sponge. The inhalation proceeds vigorously during the period of feeding, and open pores are scattered thickly over the surface of the sponge. If a little water, charged with minutely-comminuted carmine, be placed near the sponge, the molecules will be seen to be drawn slowly towards it, and their pace to rapidly accelerate until they rush into the open pores. At such times the oscula, also, are most widely extended, showing the activity of the excurrent stream. This vigorous action will last for hours; the transition from vigour to comparative quiescence is frequently marked by the closing of some of the smaller oscula, and a diminution in the diameter of the larger ones. Most of the pores also are closed, a few being left open for the promotion of a gentle current of water which seems to be necessary for conveying air into the interior. Thus, in the sponge as in the higher animals, we have alternating periods of action and repose; of strong and of calm respiratory action. Dr. Bowerbank fed a small specimen of *Spongilla fluviatilis* with finely-divided indigo, and thus describes the results: "Many of the molecules might be readily followed as they meandered through the interior of the sponge, and were seen flowing in every direction. During the maintenance of this action in full force, when I directed my attention to the osculum it was pouring forth a continuous stream of water, and along with it masses of flocculent matter, and many of the larger molecules of the indigo that had entered by the pores; but it is remarkable that although the finer molecules of indigo were being inbibed by the pores in very considerable numbers, very few of them indeed were ejected from the osculum; and if the imbibition of the molecules continues for half an hour or an hour and then ceases, the sponge is seen to be very strongly tinted with the blue colour of the indigo, and it remains so for twelve or eighteen hours, after which period it resumes its pellucid appearance, the whole of the imbibed molecules having undergone digestion in the sarcode lining the interior of the sponge, and the effete matter having been ejected through the osculum. If we kill the sponge immediately after having been thus fed, and examine the interstitial canals and cavities, we find their sarcodous surfaces thickly dotted with molecules of indigo."

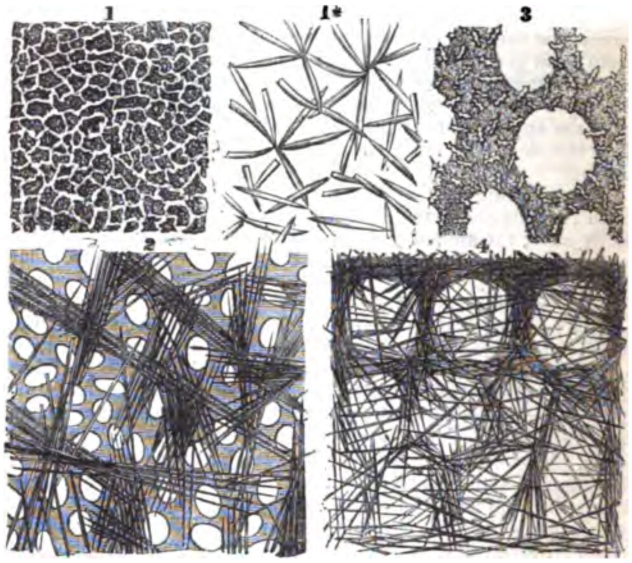


Fig. 1. Surface of the soft part in the passages of a sponge.
Fig. 1*. Network of *Isodictya varians*.
Fig. 2. Dermal surface of *Halichondria panicea*.
Fig. 3. Dermal membrane of *Tethea muricata*.
Fig. 4. Section of *Halichondria panicea*, showing intermarginal cavities.
(After Bowerbank.)

The parts connected with the creation and conduction of the currents, upon which the sponge almost entirely depends, will next engage attention. In the living state, the sponge is enveloped in a tough skin-like substance, which is the *dermal membrane.* It is apparently simple, pellucid, and unorganized; it is abundantly supplied with primitive fibrous tissue, and is lined on its inner surface with a layer of sarcode. Notwithstanding its apparent simplicity it is endowed with remarkable properties. The sponge can open pores in any part of it, and close them again without leaving any trace of their existence. If lacerated or destroyed, the injured portion is rapidly renewed. When it comes in contact with the dermal membranes of other sponges of the same species it unites with them; but no union takes place between different species. The dermal membrane is generally strengthened by a skeleton specially formed for the purpose. Thus in some of the sponges of commerce the portion of the dermis in contact with rocks, stones, or other sponges, is supported by a network of stout fibres. In *Isodictya varians* the reticulations consist of a single series of spicula, to which the membrane is attached. A portion of this framework is shown in *fig.* 1*. In *Halichondria panicea* the fibres of the network are composed of bundles of spicula cemented together as in *fig.* 2. In many cases, however, this constancy of arrangement does not prevail throughout even the same individual; thus it may happen that the spicula are matted together in places without spaces being left. According to Dr. Bowerbank, this variation in arrangement is determined by the presence or absence of pores in the dermal membrane. This membrane is also frequently supplied with beautiful stellate spicula, which are said to be serviceable as weapons of defence. They are uniformly distributed over the membrane, as seen in *fig.* 3, which represents a portion of the outer surface of *Tethea muricata;* the open spaces are the pores.

The pores, as has already been stated, are the orifices for the admission of water containing food and air. In the more highly organised sponges, such as *Pachymatisma* and *Geodia,* they are probably permanent organs, reappearing always in the same spot; but in others, such as those belonging to the *Halichondroid* type, the edges of the dermal membrane coalesce when the pores close, and when required fresh pores are opened somewhere else. The places where they may be expected to occur are where the spicula of the dermal membrane present the most regular and clearly defined network. This opening and closing of the pores occur very irregularly, and appears to be dependent on the instincts of the sponge. In sponges which frequent the rocks between high and low water marks the pores are closed, thus enabling them to retain a certain quantity of water within them. The pores are almost always closed when the sponge receives a shock. When the sponge dies, the pores remain as they were just before death. Hence in most cases sponges which are preserved in spirits seldom present any traces of pores, owing to the violence attending their collection. If the sponge be carefully removed from the water, and placed in a shallow pan of water (fresh for the fresh water, and salt for the marine species), and be allowed to die of inanition, it will most probably expire with a few if not all of its pores open.

If the current entering the pores of a *Spongilla, Grantia,* or *Halichondria* be watched, it will be noticed that the molecules do not rush straight in, but turn round the edge of the membrane, and enter at an angle of 45°. The particles then bound from one side to the opposite, and are waved from side to side should the current be weak, but if strong, they are carried forward. In the Halichondroid sponges the molecules after passing through the pores are received into large cavities which form a stratum just beneath the dermal membrane, as shown in *fig.* 4. These cavities being quite distinct from the incurrent canals into which they lead, have been termed *intermarginal cavities.* In some of the more highly organised sponges they present greater regularity and complexity of structure. A good example of this occurs in *Geodia Barretti,* in which these cavities are separated from the interstitial canals and cavities beneath by valvular diaphragms. "They are in form very like a bell, the top of which has been truncated. They are situated in the inner portion of the dermal crust; the large end of the cavity being the distal and the smaller end the proximal one. The open mouth or distal end of the cavity is not immediately beneath the dermal membrane. There is an intervening stratum of membranes and sarcode, of about the entire thickness of the dermal crust, which is permeated by numerous minute canals, which convey the water inhaled by the pores to the expanded distal extremity of the cavity. The proximal end is closed by a stout membranous valvular diaphragm (*fig.* 5), which the animal has the power of opening and closing at its pleasure. It is usually entirely destitute of the characteristic dermal spicula that are found abundantly in the adjoining membranous tissues. The action of the diaphragm of each cavity appears to be independent of the surrounding ones, the condition or degree of opening of no two adjacent ones being alike. In the greater number of cases they are in a closed state, and in this condition the membrane is filled with concentric circles composed of minute rugæ or thickened lines, and at the centre is closely pressed together, completely closing the orifice, as in *fig.* 5. In some cases the membrane is only partially closed, and the orifice is either circular or oval, as in the lower circular membrane (*fig.* 5); in others it is nearly as large as the diameter of the basal end of the cavity. The pursing of the centre of the membrane of the diaphragm is always outward as regards the cavity, so that when viewed from within it appears as a slightly funnel-shaped depression, the bottom of which is conical. The cavities are lined by a smooth and tolerably strong membrane, abundantly supplied with slender fibrous tissues, disposed in nearly parallel lines at right angles to the long axis of the cavity." (Bowerbank.)

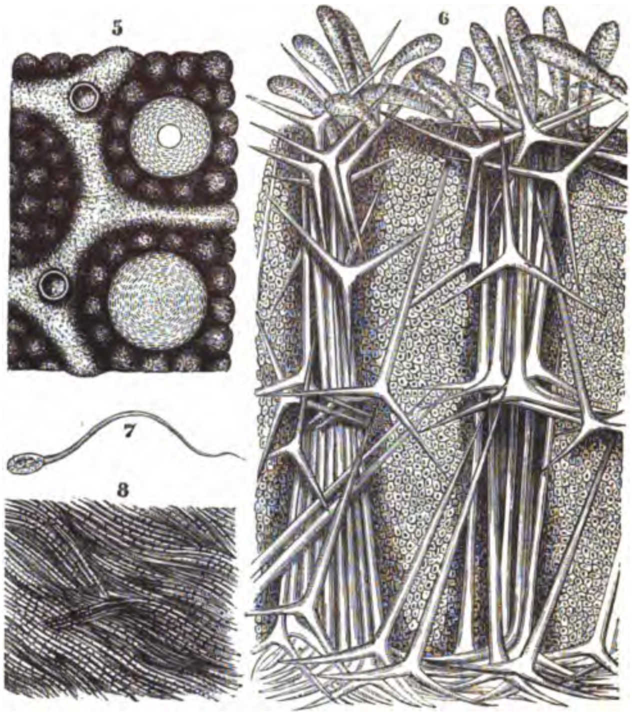


Fig. 5. Dermal crust of *Geodia Barretti.*
Fig. 6. Longitudinal section of intermarginal cavities of *Grantia compressa.*
Fig. 7. One of the detached cells of *Grantia compressa,* with the cilium in the position of action.
Fig. 8. Fibro-membranous tissue, from common sponge of commerce.
(After Bowerbank.)

These elaborate organs are supported by a beautiful network of spicula (*fig.* 5), the meshes of which are sometimes six and sometimes seven-sided. Each mesh encloses one of the membranous valves. The intermarginal cavities seem to attain their highest degree of development in *Grantia compressa* and *ciliata,* in which species they almost supersede every other organ. They form large cavities, the distal ends of which open at the outer surface of the sponge, while the proximal valvular ends open into shallow cavities, which alone remain to represent the elaborate system of incurrent canals in *Halichondria* and its allies. It is probable that the seat of the mechanism by which the currents are created rests in the intermarginal cavities, and in them only. In *Grantia* the whole of their interior is lined with cilia, and hence it has been thought probable that they subserve the purposes of respiration. Whether this is so or not is doubtful, but hitherto no signs of cilia have been detected in any other part of a sponge. The action of the cilia may be seen by tearing a living specimen of *Grantia compressa* in a direction at right angles with its long axis, placing it in a cell filled with fresh seawater, and examining the interior of some of the large cavities of the sponge under the microscope. These are the intermarginal cavities, two of which are shown in *fig.* 6. Each cavity is lined throughout with nucleated cells, having the form shown in *fig.* 7, and provided with long, slender cilia. The motions of the cilia are rapid, and cannot be followed when most active; but when somewhat languid, the action is seen to consist of a repetition of lashes, in which the upper portion of the cilium is first thrown gently backwards towards the surface of the sponge, and then lashed briskly forward in the opposite direction, or towards the osculum. The cilia act quite independently of one another. Cilia have also been seen in *Spongilla*; in *Halichondria* their presence is indicated by their peculiar effects on the molecules entering the pores, as already noticed. It frequently happens that these ciliated cells become detached, and it is probable that they have in many cases been mistaken for spermatozoa, as, for example, in Professor Huxley's description of *Tethea* in the 'Annals of Natural History,' vol. vii. 1851. Further remarks on this point will be found below in connection with the process of reproduction.

From the intermarginal cavities we pass on to the ***interstitial canals and cavities.*** In the Halichondroid sponges they form nearly the entire bulk; while in *Grantia* they are reduced to a very small proportion of it. When best developed, they consist of two distinct series of canals, the *incurrent* and *excurrent*. The incurrent series open in a few large mouths upon the intermarginal cavities from which it receives the water; it then conducts the water through a ramified system of tubes and capillaries to the innermost portion of the sponge, where it inosculates with the capillary portion of the excurrent series; these capillaries unite into large channels, which coalesce to form one or more canal by which the water is discharged through the oscula. The exceedingly large extent of surface thus comprised within a given space is perhaps the most striking feature in a sponge, and if we coincide in the opinion that the sarcode lining represents the stomach of higher animals, it may truly be said "that the aggregated surfaces become a great system of intestinal action, fully equal in proportional extent to that of the intestines of the most elaborately organised mammal." (Bowerbank.) In many sponges only one system of canals is developed, as, for instance, in the Cyathiform groups, in which the outer portion of the cup is the inhalent surface, and the interior the exhalent one; hence it is that the inner surface is more uneven than the outer, since all the oscula are there, and these in most cases have their margins slightly raised to enable the fæcal matter to be discharged without coming in contact with the contiguous surface. The lining of the canals frequently consists of highly organised membranes. Thus in the common honeycomb sponge of commerce, this lining consists of a simple interstitial membrane with a layer of primitive fibrous tissue beneath it; the arrangement of the fibrous portion is shown in *fig.* 8. In other species they are arranged in a different way. These membranes sometimes have the appearance of areolar tissue, especially when they abound in large open oval spaces.

The *oscula* form, as has been already indicated, the termination of the excurrent canals. They present various appearances in different species. In some instances they form orifices at the termination of conical elevations on the exterior of the sponge; in others they open into a single cloaca in the interior, as in *Grantia*, *Verongia*, and other fistulose sponges. They are permanent organs, but vary considerably in appearance, degree of expansion, and position. During the feeding period they are opened to their fullest extent; at other times they are much diminished in size, and even entirely closed in those littoral species that are frequently exposed to the atmosphere. The animal has the power of closing or opening any one of them independently of the others.

The most prominent, but by no means the most important, feature in sponges is the skeleton. It is composed of various materials, and presents an astonishing variety of forms and

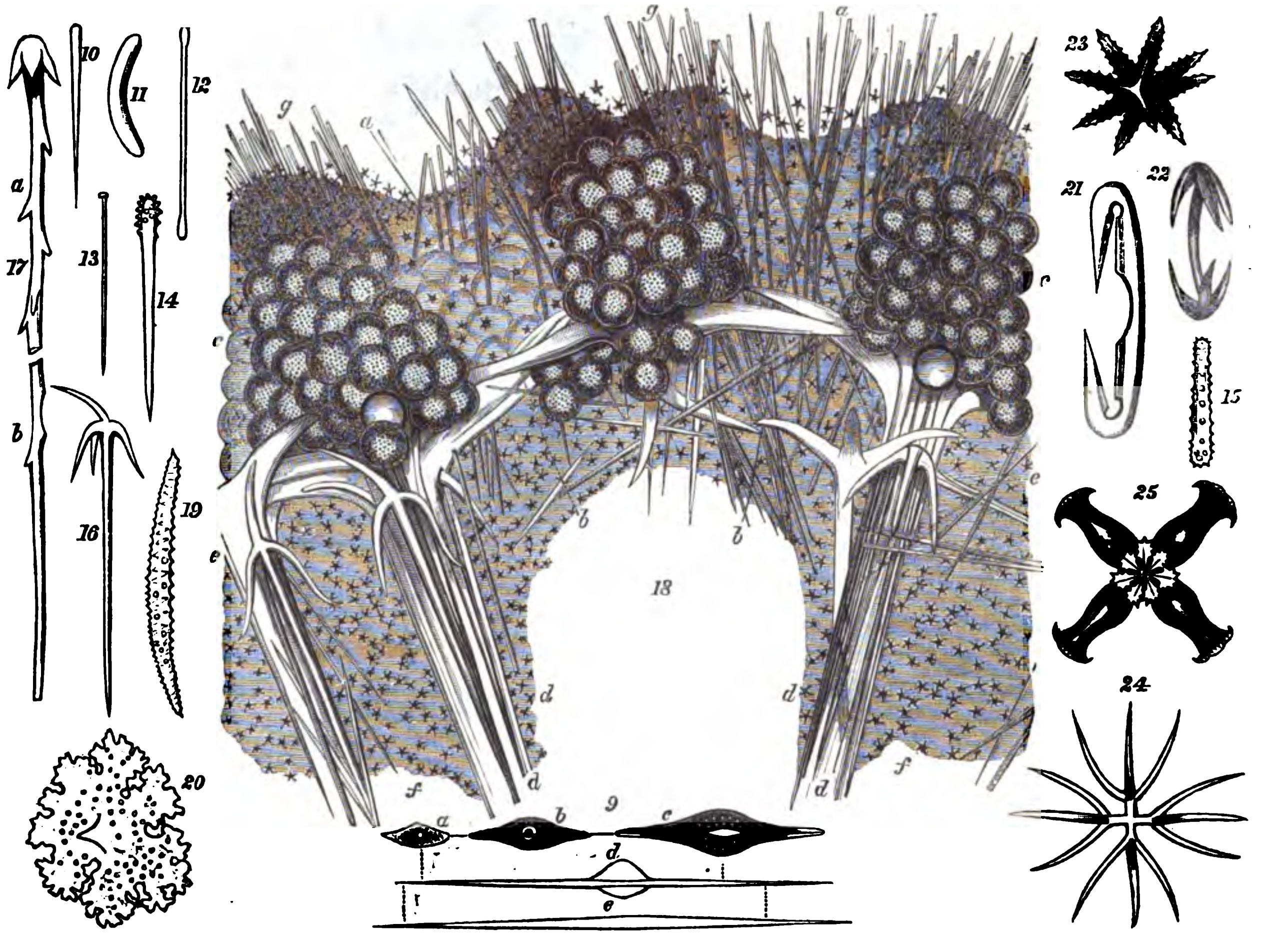


Fig. 9. Spiculum in various stages of growth. (After Bronn.)
Figs. 9—25. Spicula of various sponges.
Fig. 18 represents a portion of *Geodia Barretti*; *a*, intermarginal cavities; *b*, basal diaphragm of same; *c*, embedded ovum, forming dermal crust of sponge; *d*, large spicula, the heads of which form areas for valvular bases of intermarginal cavities; *e*, defensive spicula; *f*, portions of interstitial membrane crowded with stellate spicula; *g*, portions of secondary system of defensive spicula. (After Bowerbank.)

modes of arrangement in the parts which compose it. In one group of sponges the skeleton is principally composed of calcareous needles, or spicula, in another principally of siliceous spicula; and in another of keratose fibre. In many genera the skeleton consists partly of spicula and partly of fibre; although both these may be equally siliceous or keratose, yet they are essentially distinct. The most marked point of difference is that the spicula do not unite when in contact, while the fibre does. The spicula first appear in a thin layer of silex between two layers of membrane as in *a*, *fig.* 9; which successively assumes the forms *b*, *c*, *d*, *e*, in the case of the spindle-shaped variety. In this condition they usually possess a hollow cavity filled with a horn-like substance, or *keratode*. As this substance is combustible, while the silica is not, the extent to which it occupies the interior may readily be seen by exposing a spiculum from a young sponge in the flame of a spirit-lamp, and examining it with a microscope, when it will appear as a thick cylinder of charcoal encased in a thin tube of silica. As the sponge grows older the soft membrane is gradually replaced by silica until the central cavity can scarcely be detected. When a transverse section of a spiculum is examined the silica, or carbonate of lime, is seen to be arranged in concentric layers. The extent to which the central cavity is filled with silica does not entirely depend upon age, but is modified to suit the purposes for which the spiculum is designed. Thus in several instances it appears that the long spicula which project from the surfaces of some sponges, and which are frequently subjected to violent deflections, are almost entirely filled with keratode, although they appear to be entirely composed of silica. The long-spiked spicula projecting from *Tethea cranium*, which are so remarkable for their great flexibility, are good examples of this modification of structure. Keratode is one of the most elastic and durable animal substances known, and its combination in concentric layers with a thin external case of silica forms one of the best contrivances yet discovered for the union of strength with elasticity and durability. Similar spicula occur in *Geodia M'Andrewii*, and *Euplectella aspergillum*. The presence of spicula is so frequently associated with sponges that their occurrence in other classes of animals is apt to be forgotten. We find them in *Carpenteria*, amongst the *Foraminifera*, and in numerous genera among the *Actinozoa*, the *Tunicata*, and the *Nudibranchiata*. In sponges the spicula present an almost innumerable variety of forms, but in every case the form is evidently dependent upon certain governing laws. In most cases we find several forms in each species. In *Tethea cranium* there are no fewer than seven. Each kind is appropriated to a particular portion of the sponge for the performance of a particular function. It is owing to this dependence of form upon function that the spicula from the corresponding parts of different species present that general uniformity of character which enables the well-informed student to assign each spiculum to its proper place in the sponge. In some cases the spicula retain the same form in every stage of their development, but in others they undergo considerable variation. Any one who wishes to study the remarkable forms assumed by spicula is referred to Dr. Bowerbank's Monograph, quoted below, where most of them are figured and described. In this place a few examples only can be given. Some forms, such as those shown in *figs.* 10—15, occur in all, or nearly all, sponges, while others are restricted to certain genera and species. These latter have been classified by Dr. Bowerbank according to their functions, but in some instances the same form of spiculum serves more than one purpose. He terms them *connecting*, *prehensile*, *defensive*, *tension*, and *retentive* spicula; the spicula of the sarcode; and the spicula of the ovaries and gemmules. The connecting spicula occur in a few genera only, such as *Geodia*, *Pachymatisma*, in which they serve to connect the thick hardened surface with the mass of the animal, and occasionally act as a defensive weapon; *fig.* 16 is a spiculum of this kind from *Geodia Barretti*. Only one form of prehensile spiculum, *fig.* 17, is known. It occurs in two species of *Euplectella*. Its lower portion is free from spines, and is fixed to the base of the sponge, while the upper portion projects beyond its surface, and is so thickly beset with them, that it readily hooks on to any extraneous object near at hand. The *defensive* spicula may be either external or internal; both forms are well shown in *Geodia Barretti*, *fig.* 18, in which both the defensive and aggressive spicula (*e*) are shown just within the summits of the great intercellular spaces of the sponge, and the external defensive system at *g*. The *tension* spicula are found in the dermal membrane, where this is not strengthened by being connected with the skeleton; these are well represented by such forms as *figs.* 19, 20. The former is the more common type; the latter is noticed on account of the analogy it presents to the tension spicula in *Holothuriadæ*, and in *Brachiopoda*. *Figs.* 21 and 22 are examples of *retentive* spicula. In many species of sponge the sarcode abounds in beautiful stellate spicula, which probably assist in giving strength and firmness to it. In some instances they possess rays springing from a common centre, as in *fig.* 23, but in others they have a much more complicated structure, as, for example, in the beautiful forms shown in *figs.* 24 and 25, both of which belong to *Euplectella aspergillum*. The spicula of the ovaries and gemmules do not call for special notice here, although they are of considerable interest, inasmuch as the forms presented by them differ remarkably from those occurring in the adult sponge.

The keratode, which we have referred to as filling the interior of the siliceous spicula, is the substance which composes the horny elastic fibre of the skeleton of the common Turkey sponge. It differs widely from horn both in structure and chemical composition, but possesses a close resemblance to silk, and the skeletons of the sertularian and other zoophytes, in all of which fibrin is the most important ingredient. These fibres are cylindrical in form, and unite together to form an irregular network. In some species they have spicula enclosed in them. They are built up in concentric layers, the fresh layers being added externally. Their colour varies from an amber yellow to a deep yellow brown. In the living sponge they possess the property of uniting whenever they come in contact with the fibre of other individuals belonging to the same species.

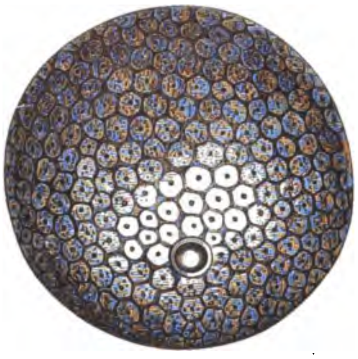


Fig. 26. Ovarium of *Spongilla fluviatilis*. (After Bowerbank.

The cellular tissue in sponges is of a very simple kind, being made up of spherical molecular, and discoid or lenticular nucleated cells. They are most conspicuous in *Grantia*, their occurrence in which genus has already been noticed.

Five modes of reproduction have been observed in sponges, viz., (1) by ova without an ovarium; (2) by ova generated within ovaria; (3) by gemmules secreted within the sponge; (4) by gemmules produced externally; and (5) by spontaneous division of the sarcode. Our knowledge of the first kind is almost entirely confined to the occurrence of minute ovoid

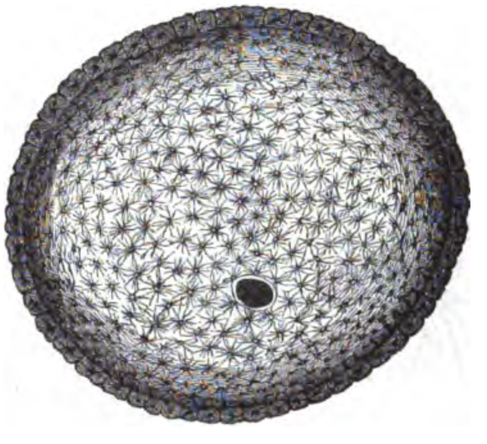


Fig. 27.—Ovarium of *Spongilla fluviatilis*, after treatment with nitric acid. (After Bowerbank.)

vesicles on the fibres of some species of *Spongia*, which vesicles are very similar to the ova liberated from the ovaria of other marine species of *Spongiadæ*. More is known of the second kind. All the ovaria have a general external resemblance, owing to their being enclosed in a coriaceous envelope; but they differ greatly in anatomical structure. They may be divided into two groups, the one typified by the ovarium of *Spongilla fluviatilis*, and the other by that of *Spongilla lacustris*. The ovaria of *Spongilla fluviatilis* occur most abundantly at its basal portion. They are spherical in form (see *fig.* 26), about $\frac{1}{50}$th of an inch in diameter, and provided with a foramen at their distal extremity. If a few of these ovaria be heated in a test tube containing some nitric acid until they become of a bright yellow colour, and the action of the acid be then stopped by diluting it with cold water, the coriaceous envelope is removed, and the arrangement of the skeleton of spicula developed, as in *fig.* 27. When examined in water or Canada balsam, under the microscope, the spicula are seen to be packed closely together, and to have the form represented in *fig.* 28. They cover the whole of the ovarium, and support the outer surface of its wall with one of the expanded extremities, and its inner surface with the other. The axes of the spicula, it will be noticed, are in lines radiating from the centre to the circumference. When the ovarium of *Spongilla lacustris* is treated in a similar way, it presents the appearance shown in *fig.* 29, in which not only are the spicula different in form, but they are arranged tangentially to the surface. Nearly all the other ovaria known conform to one or other of these types, but at the same time they present certain minor differences generally characteristic of the species or genus.

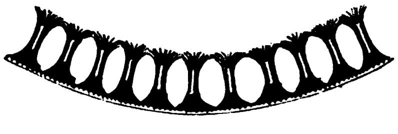


Fig. 28.—Spicula which surround the ovarium. (After Bowerbank.)

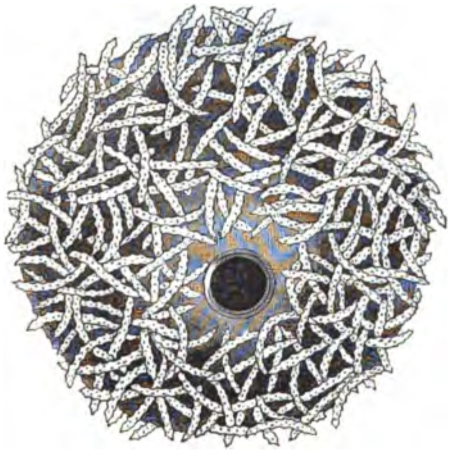


Fig. 29.—Ovarium of *Spongilla lacustris*.

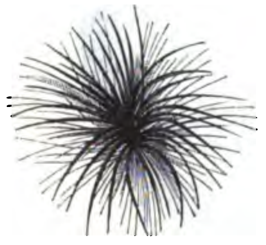


Fig. 30.—Gemmule of *Tethea cranium*.

Gemmules are distinguished from ovaria in not being ova-bearing bodies, and in being capable of development into a single individual, having the characters of the parent mass. We say capable, because it is very common for a number of gemmules to settle down in close contiguity to one another, and to merge together into one large individual. Indeed, most of the large individuals are really developed from several gemmules. The gemmules are lenticular in form, and present two distinct varieties, of different sizes. In the smaller, only one kind of spiculum is developed; in the other, there are three forms of spiculum. This distinction is constant, and Dr. Bowerbank suggests it may be sexual. The difference in the size and structure of the gemmules of *Tethea cranium* is shown in *figs.* 30, 31.

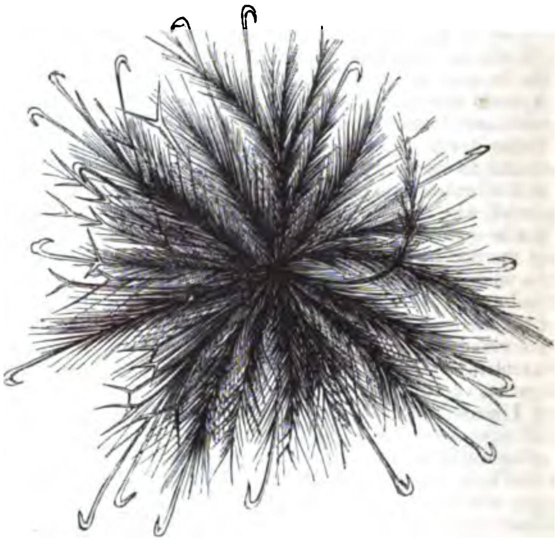


Fig. 31.—Gemmule of *Tethea cranium*.

The process of external gemmulation is only known to occur in *Tethea lyncurium*. We have lastly to notice the mode of propagation by sarcodous division, the one which is most familiar to naturalists, and which appears to be the ordinary method. It would seem that any detached portion of the sarcode has the property, either by itself or in union with other detached portions, of developing into perfect sponges. In their earliest condition they are undistinguishable from *Amœba*, and present the form seen in *fig.* 32, in which the nucleus is visible. According to some authorities, the ***swarm pores*** (one of which is shown in *fig.* 33) consist of aggregations of sarcode, and are really gemmules. Lieberkühn, however, states (A. N. H., 1856) that they have no connection with them. Those of *Spongilla* are oval in form, and visible to the naked eye. They swim for a few days by means of cilia, but always with the same end foremost. They then subside to the bottom of the vessel in which they may be, and flatten out into a delicate layer in which spicula soon appear. The swarm pores contain all the constituents of young sponges, viz., moveable cells, needles of various sizes, and some germ granules. The cilia are situated on a kind of epithelial layer of cells, each of which has one cilium. What relation these may have to the ciliary surface of the intermarginal cavity is not known.

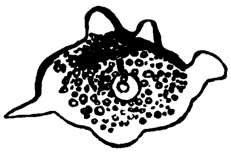


Fig. 32.—Amœbiform body of sponges.

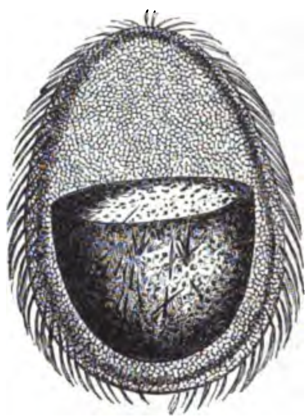


Fig. 33.—A Swarm pore. (After Bronn.

It is very doubtful if spermatozoa have really been discovered in sponges. It is true they have frequently been described by observers; but in most, if not in all cases, they have proved to be detached ciliated bodies. Lieberkühn noticed several motile corpuscles while dissecting a *Spongilla* in June, and these, he remarks, are distinguishable from the ciliary bodies of swarm pores by the much smaller head and longer and thicker tail. They are formed in globules, enveloped by a transparent structureless membrane and surrounded by sponge cells; the globules were burst by the movements of these bodies in its interior. They differ from the spermatozoa of Carter in being much smaller and in not having contractile heads; Lieberkühn suggests that Carter's spermatozoa were specimens of *Trachelius trichophorus*, which is an infusorian animalcule frequently met with inside sponges. There appears to be much resemblance between the bodies noticed by Lieberkühn and the spermatozoa of *Tethea* as described by Huxley. These last, as we have seen, are considered to be ciliary bodies by Carter. From this it will be evident there is much uncertainty on the subject. The conclusion arrived at by Dr. Bowerbank is thus stated by him, the authors referred to being those above mentioned. "On a careful consideration of the descriptions of the ciliated cells seen by the authors I have quoted above, it strikes me forcibly that the so-called zoospores and spermatozoa of Carter and Huxley are identical in origin and purpose with the similar organs described by Lieberkühn and those found *in situ* and in action in *Grantia compressa;* and in truth that they are the homologues of the breathing and feeding organs of the zoophyte and more highly organised animals." The following classification is one of the most recent, and has been proposed by Dr. Bowerbank. The names of many of the old genera are retained, but the descriptions have been modified to suit the present state of our knowledge.

Class.—PORIFERA, Grant.

Order I.—Calcarea.

Grantia, Fleming. Sponge furnished with a central cloaca, parietes constructed of interstitial cells, more or less regular and angular in form, disposed at right angles to the external surfaces and extending in length from the outer to very near the inner surface of the sponge, where each terminates in a single osculum. Type, *Grantia compressa.*

Leucosolenia, Bowerbank (*Grantia*, Fleming and Johnston). Sponge fistular; formed of a single layer of triradiate and other spicula, surrounding a large central cloaca, which extends into all parts of the sponge. Type, *Grantia botryoides*, Fleming.

Leuconia, Grant (*Grantia*, Fleming and Johnston). Sponge furnished with cloacæ, one or more; parietes of sponge formed of a mass of irregularly disposed interstitial membranes, and triradiate and other spicula; permeated by sinuous excurrent canals, the oscula of which are irregularly disposed over the surfaces of the cloacæ. Type, *Grantia nivea*, Fleming.

Leucogypsia, Bowerbank. Sponge massive, without cloacæ; formed of irregularly disposed membranous tissues and spicula; oscula at the external surface. Type, *Leucogypsia Gossei.*

Order II.—Silicea.

Sub-order 1. Spiculo-radiate skeletons; not reticulate; composed of spicula radiating in fasciculi or separately from the base or axis of the sponge.

Geodia, Lamarck. Skeleton. Spicula fasciculated, radiating from the base or central axis of the sponge to the surface; dermis crustular, furnished abundantly with closely packed ovaria; ovaria siliceous, composed of cuneiform spicula, firmly cemented together by silex, in lines radiating from the centre of the ovary; pores furnished with œsophageal tubes, terminating in the distal extremity of the intermarginal cavities; intermarginal cavities separate, symmetrical, subcylindrical; each furnished with a membranous valve at its proximal extremity. Type, *Geodia gibberosa.*

Pachymatisma, Bowerbank. Skeleton composed near the external surface occasionally of short fasciculi of siliceous spicula, disposed in lines at about right angles to the surface of the sponge; central portion of the sponge unsymmetrical; dermis crustular, furnished abundantly with closely packed ovaria; ovaria siliceous, formed of cuneiform spicula, firmly cemented together in lines radiating from the centre of the ovary; pores furnished with œsophageal tubes, terminating in the distal extremity of each intermarginal cavity; intermarginal cavities symmetrical, subcylindrical, with a pyloric valve at the proximal end of each. Type, *P. Johnstonia.*

Ecionemia, Bowerbank. Sponge having a strong axial column or centre of closely packed siliceous spicula, disposed in lines parallel to the long axis of the sponge, from which axial column or centre a peripheral system of spicula radiates at about right angles; distal ends of the radii furnished more or less with ternate connecting spicula, the radii of which are disposed immediately beneath the dermal membrane. Type, *E. acervus.*

Alcyoncellum, Quoy and Gaimard (*Euplectella*, Owen). Sponge fistulate; fistula single, elongate, without a massive base. Skeleton: primary fasciculi radiating from the base in parallel straight or slightly spiral lines; secondary fasciculi at right angles to the primary ones; oscula congregated, with or without a marginal boundary to their area. Type, *A. corbicula.*

Polymastia, Bowerbank. Skeleton. Basal mass; central portion consisting of a plexus of contorted anastomosing fasciculi, resolving themselves near the surface into short straight bundles, disposed at nearly right angles to the surface. Oscula congregated, elevated on numerous long fistulæ. Fistulæ composed of numerous parallel fasciculi, radiating from the base to the apex of each in straight or slightly spiral lines. Type, *P. mammillaris.*

Halyphysema, Bowerbank. Sponge consisting of a hollow basal mass, from which emanates a single cloacal fistula. Skeleton: spicula of the base disposed irregularly; spicula of the fistula disposed principally in lines parallel to the long axis of the sponge, without fasciculation. Type, *H. Tumanowiczii.*

Ciocalypta, Bowerbank. Skeleton composed of numerous closed columns, each consisting of a central axis of compact, irregularly elongated, reticulated structure, from the surface of which radiate at about right angles numerous short, simple, cylindrical pedicles or stout fasciculi of closely packed spicula; the distal ends of each pedestal separating and radiating in numerous curved lines which spread over the inner surface of the dermal membrane, separating and sustaining it in all parts at a considerable distance from the central axis of the skeleton. Type, *C. penicillus.*

Tethea, Lamarck. Sponge massive, suborbicular. Skeleton consisting of fasciculi of spicula. Fasciculi radiating from a basal or excentrical point to the surface. Intermarginal cavities unsymmetrical, confluent. Propagation by internal or external gemmulation. Types, *T. lyncurium*, Linnæus; *T. cranium*, Lamarck.

Halicnemia, Bowerbank. Skeleton formed of a single superior stratum of spicula radiating from the centre to the circumference of the sponge at about its middle, and of an inferior stratum of spicula distributed without order. Type, *H. patera.*

Dictyocylindrus, Bowerbank. Skeleton; without fibre; composed of a loosely compacted columnar axis of spicula, disposed principally in the line of the axial column, from which a peripheral system of long single or fasciculated defensive spicula radiate at right angles to the axial column. Type, *D. hispidus.*

Phakellia, Bowerbank. Skeleton composed of a multitude of primary cylindrical axes, radiating from a common base and ramifying continuously, from which emanate at about right angles to the axes a secondary series of ramuli, which ramify continuously as they progress towards the surface, but never appear to anastomose. Type, *P. ventilabrum.*

Microciona, Bowerbank. Skeleton. A common basal membrane, whence springs at or about right angles to its plane numerous separate columns of spicula intermixed with keratode; furnished externally with spicula which radiate from the columns at various angles towards the dermal surface of the sponge. Type, *M. atrasanguinea.*

Hymeraphia, Bowerbank. Skeleton. A single basal membrane, whence spring numerous large separate spicula, which pass through the entire thickness of the sarcodous stratum to or beyond the dermal surface of the sponge. Type, *H. stellifera.*

Hymedesmia, Bowerbank. Skeleton. A common basal membrane sustaining a thin stratum of disjoined fasciculi of spicula. Type, *H. Zetlandica.*

Sub-order 2. Spiculo-membranous skeletons, composed of interstitial membranes, having the skeleton spicula irregularly dispersed on their surfaces.

Hymeniacidon, Bowerbank. Skeleton without fibre, spicula without order, imbedded in irregularly disposed membranous structure. Type, *H. caruncula.* The genera *Halina*, Bowerbank; and *Halisarca*, Dujardin, are included in this.

Sub-order 3. Spiculo-reticulate skeletons. Skeletons continuously reticulate in structure, but not fibrous.

Halichondria, Fleming. Sponge without fibre; composed of an irregular polyserial network of spicula cemented together by keratode. Type, *H. panicea*, Johnston.

Hyalonema, Gray. Skeleton an indefinite network of siliceous spicula, composed of separated elongated fasciculi, reposing on continuous membranes, having the middle of the sponge perforated vertically by an extended spiral fasciculus of single, elongated, and very large spicula, forming the axial skeleton of a columnar cloacal system. Type, *H. mirabilis*, Gray.

Isodictya, Bowerbank. (*Spongia*, Montagu; *Halichondria*, Fleming and Johnston.) Skeleton without fibre; composed of a symmetrical network of spicula; the primary lines of the skeleton passing from the base or centre to the surface, and the secondary lines disposed at about right angles to the primary ones. Propagation by internal membranaceous, aspiculous gemmules. Types, *I. palmata* and *Normani*, Bowerbank.

Spongilla, Linnæus. (*Halichondria*, Fleming.) Skeleton without fibre, composed of a symmetrical network of spicula; the primary lines of the skeleton passing from the base or centre to the surface, and the secondary lines disposed at about right angles to the primary ones. Reproductive organs, ovaries, coriaceous and abundantly spiculous. Type, *S. fluviatilis*, Linnæus.

Sub-order 4. Spiculo-fibrous skeletons. Regularly fibrous. Fibres filled with spicula.

Desmacidon, Bowerbank. (*Halichondria*, Johnston.)—Skeleton fibrous, irregularly reticulated. Fibres composed entirely of spicula arranged in accordance with the axis of the fibre, cemented together and thinly coated with keratode. Type, *D. fruticosa*, Bowerbank.

Raphyrus, Bowerbank. Skeleton fibrous, but not horny. Fibre composed of a dense mass of siliceous spicula mixed together without order. *R. Griffithsii* is the only species known.

Sub-order 5. Compound reticulate skeletons, having the primary reticulations fibro-spiculate, and the interstices filled with a secondary spiculo-reticulate skeleton.

Diplodemia, Bowerbank. Skeleton fibrous. Fibres keratose, hetro-spiculous; combined with a secondary skeleton of irregular network of spicula; rete unispiculate, rarely bispiculate. Ovaries membranous and spiculous. Type, *D. vesicula*, Bowerbank.

Sub-order 6. Solid siliceo-fibrous skeletons. Skeletons reticulate. Fibres composed of concentric layers of solid silex, without a central canal. Reticulations unsymmetrical.

Dactylocalyx, Stutchbury. Skeleton siliceo-fibrous. Fibres solid, cylindrical. Reticulations unsymmetrical. Type, *D. pumicea*, Stutchbury.

Sub-order 7. Canaliculated siliceo-fibrous skeletons. Skeletons reticulate, symmetrical. Fibres composed of concentric layers of solid silex, with a continuous central canal.

This is founded on some fragments of sponges of unknown species, and upon some fibres referred to a species provisionally named *Farrea occa.*

Order III.—Keratosa.

Sub-order 1. Solid non-spiculate kerato-fibrous skeletons.

Spongia, Linnæus. Skeleton kerato-fibrous. Fibre solid, cylindrical, aspiculous. Rete unsymmetrical. Type, *S. officinalis*, Linnæus.

Spongionella, Bowerbank. (*Spongia*, Sowerby and Johnston.) Skeleton kerato-fibrous. Fibres solid, cylindrical aspiculous. Rete symmetrical; primary fibres radiating from the base to the apex. Secondary fibres disposed at nearly right angles to the primary ones. Type, *S. pulchella*, Bowerbank.

Sub-order 2. Solid, semi-spiculate, kerato-fibrous skeletons.

Halispongia, De Blainville. Skeleton kerato-fibrous. Fibres solid; primary fibres compressed, containing an irregularly disposed series of spicula. Secondary series of fibres unsymmetrical, cylindrical, without spicula.

Sub-order 3. Solid, entirely spiculate, kerato-fibrous skeletons.

Chalina, Grant. Skeleton fibrous. Fibres keratose, solid, cylindrical, and interspiculate. Rete symmetrical; primary lines radiating from the basal or axial parts of the sponge to the distal portions. Secondary lines of fibre at about right angles to the primary ones. Type, *C. oculata*, Bowerbank.

Sub-order 4. Simple fistulo-kerato-fibrous skeletons.

Verongia, Bowerbank. (*Spongia*, Lamarck.) Skeleton kerato-fibrous. Fibres cylindrical, continuously fistulose, aspiculous. Rete unsymmetrical. Type, *V. fistulosa.*

Sub-order 5. Compound fistulo-fibrous skeletons.

Auliskia, Bowerbank. Skeleton kerato-fibrous. Fibres aspiculous, cylindrical, continuously fistulose, primary fistulæ having many cæcoid canals radiating from them in every direction. Rete unsymmetrical.

Sub-order 6. Regular semi-areno-fibrous skeletons.

Stematumenia, Bowerbank. Skeleton. Primary fibres solid, more or less compressed, containing a central axial line of spicula and grains of extraneous matters. Interstitial structures abundantly fibro-membranous.

Sub-order 7. Irregularly and entirely areno-fibrous skeletons.

Types, *Dysidea fragilis*, Johnston; *Dysidea Kirkii*, Bowerbank. (Bowerbank, *Monograph of British Spongiadæ.*)

SPRINGS. The articles in E. C. which relate to this subject have been inserted in both the present division and in that which relates to the arts and sciences. Details are given under Water, E. C. in the Nat. Hist. Div.; and under Artesian Wells, Buxton Waters, Cheltenham Waters, Lakes, Mineral Waters, Springs, Water, E. C., Arts & Sci. Div. As the great bulk of the information is incorporated in the last-mentioned division, and as the subject properly belongs to physical geography, the articles relating to which are mostly contained in the same division, it seems preferable to make a cross reference to Springs, E. C. S., Arts & Sci. Div., than to give supplementary details in this place.

SQUALIDÆ [E. C. iv. cols. 883—886]. The sharks perform the same predatory functions in the sea which the eagle and cat tribe perform in the regions above the sea. Their skeleton is mostly composed of a tough cartilaginous basis, which, however much it may resemble the early state of the vertebrate embryo, seems to be adapted for the active habits of these creatures, and to be associated with a high organization of the soft parts. The muscles are powerful, firm, and so arranged as to enable the shark to direct their movements with greater precision than in most fishes, while their strength enables them to sustain continuous action for a surprisingly long period. The eye is provided with a sort of eyelid in some species, is supported on a pillar within the orbit, and is supplied with long and strong muscles, which facilitate its rapid motion. The long pedicles are extraordinarily well developed in the hammer-headed shark, the lateral projections being due to the extended orbital supports.

Although sharks are plentiful in foreign seas, and occur in many of the geological strata, we shall confine our supplementary remarks to the British species.

Scyllium canicula. It frequents the shore, and lives principally upon crustaceans. The individuals which occur on rocky ground are usually darker-coloured than those which tenant more open places. When seized, it lashes its body round the arm, and rasps off the skin by means of its sharp rugged skin. This illustrates one use of the roughened skin, as also the great power of the body muscles. It attains a length of four or five feet, and a girth at the widest part of about thirteen inches. This is one of the species which lays its eggs in the so-called sea-purses. According to Couch, this species is called the Nurse Hound, while the name of Lesser Spotted Dogfish is given to the species next mentioned.

S. catulus. It has somewhat similar habits as *S. canicula.* Its egg-case differs in several particulars from that of *S. canicula.* Thus it has a slit at each corner, while that of the other species has no slit at all. What the use of the slits may be has not been satisfactorily ascertained. That they are not intended for the admission of sea-water is manifested by the circumstance that the presence of that fluid destroys the embryo if not sufficiently developed.

Pristiurus melanostomus (the Black-mouthed Dogfish). This was referred by Yarrell to *Scyllium*, but as it has the saw-like structure on the upper margin of the tail, it is more correctly placed in the genus *Pristiurus*. It occurs on the coasts of

England, but is more abundant farther south, as at Madeira and in the Mediterranean.

Notidanus griseus is a large shark, sometimes attaining a length of ten or eleven feet. It appears to be a ground-frequenter. Only a few British examples have been found.

Carcharias vulgaris (the White Shark). It is possible that two species are confounded under this name, since the best known form, or that which frequents the West Indian seas, is said to have no spiracles behind the eye, whereas in one specimen found on British shores a minute spiracle has been found. As one of the characters distinguishing the genus *Carcharias* is the absence of spiracles, the specimen alluded to will probably be referable to the genus *Galeus*. The White Shark is one of the most dreaded of fishes, but it seldom visits British seas.

C. glaucus (the Blue Shark). It visits the British isles in summer, and sometimes goes as far north as the Orkneys. It does much damage to nets when hunting for fish. It cuts the pilchards and herrings out of the drift nets with its sharp teeth, and swallows both the fish and the portion of net which has been detached. In seizing its prey it turns over with a rolling motion. Occasionally it bites at a fisherman's line, which, being divisible with difficulty on account of its slenderness permitting it to get between the teeth, the fish rolls over and over and is so entangled in the line that it can be pulled up to the surface. Its size is sometimes as much as fourteen feet from end to end.

Alopecias vulpes (the Thresher). Cuvier referred it to *Carcharias*, but Couch gives it the above name. It is credited with being one of the great enemies of whales, which it is said to frighten by lashing the sea with its long tail. Whatever may be the reason for splashing the surface of the sea, it certainly has no power to frighten or to seriously molest whales. The usual length is about 12 feet, but some specimens are 15 or 16 feet long. The upper lobe of the tail is of extraordinary dimensions, being nearly as long as from the origin of the tail to the snout.

Lamna cornubica (the Porbeagle). It is a common summer visitor on the western coasts of the British isles. It travels in small companies, pursuing small fishes.

Galeus vulgaris (the Toper). It is a common British fish, swims low in the water, and seldom inflicts injuries on fishermen's nets. The old ones leave our shores in winter, but many of the young ones remain.

Mustelus lævis (the Smooth Hound). It is common on our southern shores, but rather rare off Scotland. It seems to return towards the south in the winter months.

Spinax vulgaris (the Picked Dog). It is the most abundant of British sharks, and is pre-eminently the dogfish. It is found everywhere on our coasts all the year round. Its numbers are sometimes prodigious, the sea for many square miles swarming with dogfish. It does great injury to fishermen by mangling their nets and fish. It is a common belief that it cuts away the lines by means of the sharp spines in front of the dorsal fins. This does not seem probable; yet, when laid hold of by the head they can bend the back over and give a lashing cut with the spines.

Scymnus spinosus (the Spinous Shark). It occurs at the Cape of Good Hope, in the Mediterranean, and rarely on the British coasts. Its shape is very different from that of most of the sharks already mentioned, being short and clumsy where they are lithe and slender. Its fins and tail are small. In accordance with this, it seems to spend an inactive life on the sea bottom and in deep water.

The other British species are *Scymnus borealis*, the Greenland Shark; *Selache maximus*, the Basking Shark; *Polyprosopus Rashleighanus*, the Rashleigh Shark; *P. macer*, the Broad-headed Gazer; *Zygæna malleus*, the Hammer-head; and *Squatina vulgaris*, the Monkfish. The last-named approaches in appearance the allied group of Rays, which is represented by such genera as *Cephaloptera*, &c. a notice of which will be found under RAIIDÆ, E. C.

(Couch, J., *History of British Fishes*, vol. i.)

STARCH. This substance, as has already been stated in this Cyclopædia, is widely spread through the tissues of plants, in the first formation of which it plays a highly important part. At one time it was regarded as a substance peculiar to plants, and was even proposed as a test for distinguishing them from animals in cases of doubt. It has, however, been found in various zoological groups from sponges to man, but it does not have the same importance in the growth or development of animals as it has in plants. There is, however, another substance closely allied to starch which has received various names, such as the amyloid substance of Bernard; animal dextrine; zoamyline; and glycogenic substance.

Like starch and dextrine, it has a composition answering to the formula, $C_6 H_{10} O_5$, but it differs from them in physical properties. It is a white substance, having neither odour nor taste, which resembles dextrine, but differs from starch in being soluble in water, while it agrees with both in being insoluble in concentrated alcohol. Dextrine is soluble in dilute alcohol, which is not the case with the amyloid substance of Bernard, nor with starch. It is like starch, but unlike dextrine in being susceptible of fermentation; and it is like dextrine, but unlike starch, in not giving a blue colouration with iodine, and in reducing the cupro-potassic solution. The brown colour which it presents when in contact with iodine is one of the chief characteristics of this peculiar substance.

It was first discovered in the liver of animals, and was supposed to have some connection with the sugar-forming function of the liver, whence Bernard called it glycogenic substance. Further investigations indicate that it may be to animals what ordinary starch is to plants. At present our knowledge is very incomplete as regards both the function of this amyloid substance in the animal system and the molecular structural conditions which cause it to be physically different from starch and dextrine. It appears, however, that in the young embryos of mammalia it is abundantly distributed through all the tissues; that at a later stage it preponderates more in one than another, more particularly in those from which the horny parts are being developed. Thus it occurs in the developing hoof, horns, and other horny tissues; it may be found wherever the little patches of hair first make their appearance, gradually decreasing as they grow, and disappearing almost entirely as soon as they are completely formed. In like manner it occurs in large quantities in the earliest stages of the other tissues, diminishing in quantity as they acquire form, and disappearing when they are fully formed. At present little is known as to the order in which the various tissues are deprived of it—a subject which presents much interest to the physiologist, and which promises

SIZE AND CONDITION OF EMBRYO.	LUNG.		MUSCLES.		HEART.	
	Quantity of		Quantity of		Quantity of	
	Tissue.	Amyloid substance.	Tissue.	Amyloid substance.	Tissue.	Amyloid substance.
	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
Four inches long	—	—	30	·1	—	—
Not quite six inches long; without any vestige of hair	20	1·9	60	—	—	—
Seven inches long; a trace of hair on the lip	20	2·55	60	·5	20	1·52
Ten inches long; delicate hair about the head	20	2·8	60	1·1	20	1·60
Fifteen inches long; covered with delicate hairs	20	3·45	60	2·0	20	1·76
Sixteen-and-a-half inches long; well covered with fine hair . . .	20	2·2	60	2·1	—	—
Nearly 20 inches long; quite thickly covered with wool, and evidently very near the time of birth	20	A quantity too small to be estimated.	60	1·4	20	A trace too small to weigh.

to furnish him with an important field of research. In the preceding table is indicated the quantity of amyloid substance in a few of the tissues of the fœtal lamb at various stages of its development. The facts here presented are approximately the same in various other animals, such as the rabbit, the cow, the dog, and the rat. In the lung it is so abundant at one period as to constitute more than half of the dry tissue; while at the moment of birth it has so far diminished as to be almost inappreciable. In the voluntary muscles it increases until the embryo is nearly 16½ inches in length, after which it diminishes, although still abundant at the period of birth; it gradually lessens after birth, and disappears entirely in the course of a few weeks. In the muscular tissue of the heart a trace only of the amyloid substance can be detected in the embryo almost ready for birth. It is interesting to notice that amyloid substance remains in the voluntary muscles up to the period when they are called into full activity, which is some weeks after the birth of the lamb; while it has disappeared at a much earlier stage from the muscular tissues of the heart, which is in full exercise some time before the birth of the embryo. It appears very late in the lung, and is by no means so abundant in that of the newborn lamb as in that of the adult sheep. In all adult mammals the amyloid substance is chiefly confined to the liver. In most cases none is to be found in the muscles of adults, but it has been occasionally detected in the flesh of such as have been fed on substances containing much starch or sugar, and it is frequent in the flesh of hybernating animals.

STRIATOPORA. A genus of *Actinozoa*, established by Hall in 1852. It is represented by a single species, *S. flexuosa*, which has been found in the Niagara group of rocks over a small area in the neighbourhood of the Niagara Falls.

STRONTIA. This oxide has been found, but in very minute quantities, in many mineral waters; for instance, the springs at Salzbrunn, Aix-la-Chapelle, Burtscheid, Pyrmont, Meinberg, Ems, and elsewhere. Its general, or, at any rate, frequent presence in springs implies a wide distribution of it in the rocks through which such springs flow. Its occurrence in rocks has, however, only been occasionally noticed, probably owing to the minute quantity present in most cases, and to the practical difficulty of detecting it. Gmelin found traces of it in basalt at Stetten, and Rammelsberg in basalt near Carlsbad. It has been detected in calcspar, arragonite, and dolerite.

Cœlestine (sulphate of strontia) is frequently associated with gypsum and sulphur, and is most frequently found in fissures, metalliferous veins, and drusy cavities. It sometimes enters into the composition of many of the secondary fossils; for example, some of the ammonites from the lias, the chambers of which are occasionally lined with crystals of cœlestine. Fine crystals have been found in other places besides Sicily, amongst others, Bex, in Switzerland; Conil, in Spain; Retzbanya, in Hungary; and the compact limestone near Lake Erie. The blue colour in some specimens of cœlestine has been attributed to phosphate of iron.

Baryto-cœlestine. Two minerals, both composed of sulphate of baryta and sulphate of strontia, but in different proportions, have been thus named. One occurs at Kingston, Canada, and the other near Binnenthal, in Switzerland.

T

TACONIC SYSTEM. The name given by Professor Emmons to a thick series of rocks which occur in North America. He maintained that these rocks were the oldest in the world, and that they contained the relics of primæval life. He wrote work after work to prove that they were older than the Potsdam sandstone. The recent palæontological and stratigraphical evidence which has been accumulated, chiefly by the officers of the Geological Survey of Canada, have conclusively shown that these rocks correspond in age with the Potsdam sandstone and the strata which immediately overlie it. A general account of these beds is therefore given under QUEBEC GROUP, E. C. S.

TEPHROITE is a dibasic silicate of manganese analogous to the dibasic silicates, willemite, fayalite, olivine, and a few more. It presents some points of resemblance to rhodonite, which is the monobasic silicate of manganese, especially as regards the changes it undergoes when exposed to atmospheric influences. The hardness is 5·5—6; the specific gravity, 4—4·12; the lustre adamantine; and the colour greyish flesh-red, reddish brown, and rose-red to ash-grey. When exposed to the air the tint becomes brown and black, owing to the formation of manganic oxide. It occurs at Sparta, New Jersey; at Paisberg, in Sweden; and Sjogrufvan. An unsually pure specimen analysed by Rammelsberg gave a composition of 28·66 per cent. of silica, 2·92 of ferrous oxide, and 68·88 of manganous oxide. The theoretical composition is 29·8 per cent. of silica, and 70·2 of manganous oxide. The manganous oxide is partially replaced in some specimens by magnesia and zinc oxide.

(Dana, *A System of Mineralogy*, 5th Ed.).

TERTIARY STRATA [E. C. vol. iv. cols. 1043—1045]. Additional details respecting these strata will be found under the headings EOCENE, MIOCENE, and POST-PLIOCENE in this Supplement. In this place we would simply indicate how difficult it is to apply the principle of per-centage employed by Sir C. Lyell in the classification of these strata. The difficulty arises from two sources, the uncertainty as to what groups of shells constitute unquestionable species, and the frequency with which shells derived from the older rocks are considered to have been living at the time when the deposits in which they occur were formed. For example, in Sir C. Lyell's 'Elements of Geology,' the Red Crag of Suffolk is said to have yielded 219 species of marine *Mollusca*, of which 132 are still living, and 87 are extinct. The recent species here constitute 60 per cent. of the whole fauna. Prestwich, in 1868, estimated the number of reputed species of *Mollusca* at 245, of which 99 are extraneous fossils and varieties. Of the 146 species which are considered to belong to the Red Crag itself, 133, or 92 per cent., are identified by Jeffreys as recent. The same kind of thing occurs with other beds, so that it is not easy to say within 30 or 40 per cent. what proportion the species which have lasted to the present bear to those which have become extinct. All the crags belong to the pliocene group.

THALASSOPHRYNE, a genus of fishes belonging to the family *Batrachidæ*, and remarkable as comprising species which are provided with what are decided to be real poison organs analogous to the poison fangs of serpents. Many species of fish have had the reputation of being able to inject a poison into wounds on account of the intense pain which follows a stroke of their defensive or offensive spines, but on examination no indication of a poison-secreting apparatus has been discovered. Thus one species of *Trachinus* found on British shores, *T. draco*, has spines on each side of its head with which it can inflict a wound which causes intense pain all up the arm, when the hand is struck, which lasts for many hours. *Thalassophryne reticulata* is a species new to science, but which has been long known to the fishermen of Panama, who are well acquainted with the presence and function of its spines, since they say a poison is injected from them which, when introduced into a wound, causes a fever, but the illness seldom or ever proves fatal. The poisonous organs consist of four hollow spines, two of which are dorsally situated, and the other two form the backward projections of the opercula. The channel in each spine is connected with a small sac, which will jet out a fluid to the distance of several inches on being slightly pressed with the finger. Dr. Günther believes the sacs are merely reservoirs, and that the true secreting organ is the system of muciferous channels. *T. maculata* also possesses this poison apparatus.

(Günther, *Proc. Zool. Soc. for* 1864, p. 155; Dow, *Proc. Zool. Soc. for* 1865, p. 677.)

THISANTHA, a genus of Crassulaceous plants, comprising a few species only, all of which are confined to the Cape of Good Hope, a locality where the house-leek tribe is so abundantly developed. The species were formerly merged in the genus *Crassula*, but are now considered to be generically separable therefrom.

TRACHINIDÆ, an extensive family of Acanthopterygian fishes, the English species of which are commonly known as Weevers. The following synopsis of the group is condensed from Dr. Günther's work cited below. The family is defined in the following terms. Body elongate, low, naked, or covered with scales. Teeth in villiform bands, with pointed and conical canines in some of the genera; no molars or trenchant teeth. The infraorbital ring does not articulate with the præoperculum. One or two dorsal fins, the spinous portion being always much less developed and shorter than the soft; the anal similarly developed as the soft dorsal. Gill opening more or less wide; five, six, or seven branchiostegals; pseudobranchiæ. No prominent papillæ near the anus. Air-bladder generally absent; pyloric appendages in moderate number or wanting. Vertebræ, $\frac{10 \text{ or } 10+x}{14+y}$. All the species are carnivorous, and ground frequenters.

Dr. Günther divides the family into four groups or sub-families. The first group, or *Uranoscopina*, has the eyes on the upper surface of the head; the cleft of the mouth vertical, and the head generally armed with bony plates. The body is sometimes naked, and sometimes covered with small scales to a greater or less extent. The lateral line is uninterrupted. It embraces the following five genera:—

Uranoscopus. Head large, partly covered with bony plates; body somewhat cylindrical; cleft of the mouth vertical; eye on the upper side of the head. Scales very small. Two dorsals, the first with three to five spines; ventrals jugular; pectoral rays branched. Villiform teeth in the jaws, on the vomer and the palatine bones, without canines; generally a filament below and before the tongue; opercular apparatus generally armed; cavity of the gills with an opening above the operculum as well as posteriorly. Pseudobranchiæ; six branchiostegals. Air-bladder none; pyloric appendages in moderate number. Ten species are enumerated and described by Dr. Günther. The range is very wide, species occurring in the Atlantic, Indian, and Pacific Oceans, and in the Mediterranean Sea.

Agnus. Habit and teeth as in *Uranoscopus.* Scales none. Two dorsals, the first with about four spines; ventrals jugular; pectoral rays branched. No filament in the mouth; some bones of the head armed. Six branchiostegals. Air-bladder none. Only one species mentioned, which inhabits the American side of the North Atlantic.

Anema. Habit and teeth as in *Uranoscopus.* Scales very small. No filament in the interior of the mouth. One continuous dorsal; ventrals jugular; pectoral rays branched; some bones of the head armed. Six branchiostegals; pseudobranchiæ. Cavity of the gills without superior opening. Air-bladder none; pyloric appendages in moderate number. There are three species which frequent the Australian and Indian seas.

Kathetostoma. Habit and teeth as in *Uranoscopus.* Scales none. One continuous dorsal; ventrals jugular; pectoral rays branched; some bones of the head armed. Cavity of the gills without superior opening; six branchiostegals; pseudobranchiæ. Air-bladder none. The only species recorded is Australian.

Leptoscopus. Form of the head as in *Uranoscopus*, but entirely covered with soft skin; body elongate; cleft of the mouth approaching the vertical line; eye on the upper side of the head. Scales small, cycloid. One continuous dorsal; ventrals jugular; pectoral rays branched. Villiform teeth in both the jaws, on the vomer and the palatine bones; without canines. No interior or exterior filament; opercles without external spines. Cavity of the gills very wide, partially opened above. Six branchiostegals; pseudobranchiæ. Neither an air-bladder nor pyloric appendages. *L. macropygus*, the only species, is known from but one locality, the neighbourhood of Port Jackson, New South Wales.

The second group, or *Trachinina*, has the eyes more or less lateral. The head is not plated. The lateral line is continuous, and the intermaxillary is without the larger tooth on its posterior portion. It embraces ten genera, having the following definitions:—

Trachinus. Body cylindrical, elongate; cleft of the mouth very oblique; eye lateral, directed upwards. Scales very small, cycloid. Two dorsals, the first short, with six or seven spines; ventrals jugular; the lower pectoral rays simple. Villiform teeth in the jaws, on the vomer, the palatine, and pterygoid bones. Præorbital and operculum armed. Six branchiostegals; pseudobranchiæ. Air-bladder none; pyloric appendages in small number. There are five species, of which four occur in the Mediterranean, and three of these range into the Atlantic. One species exists on the coast of Chili. Two of the species belong to the British fauna, viz., *T. draco* and *T. vipera.* The usual habit of *T. draco* is to half bury itself in the sand, digging a hole by means of its tail, and then covering itself up so as to expose the head only. In this position it awaits, with an expectant, ready attitude, the approach of some fish on which it may spring. Frequently, however, the tide ebbs while it is thus concealed, and persons seeing it have thought it to be stranded, and have received serious wounds on grasping it. The weapons of offence are the spines on each side of the head. The puncture induces great pain, but no poisonous fluid is exuded. Its range south extends to the Cape of Good Hope. *T. vipera* is common on British shores, and has similar habits to the last-mentioned species.

Percis. Body cylindrical, elongate; cleft of the mouth slightly oblique; eye lateral, directed upwards. Scales small, ctenoid. Dorsals more or less contiguous, the spinous with five or four spines; ventrals a little before the pectorals; the lower pectoral rays branched. Villiform teeth in the jaws, with the addition of canines; teeth on the vomer, none on the palatines. Operculum with two small spines; præoperculum entire or slightly denticulated. Six branchiostegals; pseudobranchiæ. Air-bladder none; pyloric appendages in small number. The fourteen species described live in the Indian, Australian, and the western portion of the Pacific, Oceans.

Aphritis. Cylindrical, elongate; cleft of the mouth slightly oblique, with the lower jaw rather longer; eye lateral. Scales rather small, minutely ciliated. Two separate dorsals, the first with six spines; ventrals jugular, with one spine and five soft rays; the lower pectoral rays branched. Villiform teeth in the jaws, on the vomer, and the palatine bones, without canines. Six branchiostegals. Air-bladder none; pyloric appendages in small number. There are three species; one frequents the fresh waters of Van Diemen's Land, the other two occur on the west coast of South America. The latter may, however, belong to a distinct genus.

Sillago. Body somewhat cylindrical, elongate; cleft of the mouth small, with the upper jaw rather longer; eye lateral, somewhat directed upwards. Scales rather small, ctenoid. Two dorsals, the first with nine to twelve spines; ventrals thoracic; the lower pectoral rays branched. Villiform teeth in the jaws and on the vomer, none on the palatines. Operculum terminating in a point; præoperculum denticulated. The bones of the head with the muciferous system developed. Six branchiostegals; pseudobranchiæ. Air-bladder simple; pyloric appendages in small numbers. There are eight species which frequent the oceanic areas bounded by the south coasts of Asia and by Australia.

Eleginus. Body elongate, somewhat cylindrical; cleft of the mouth small, with the upper jaw rather longer; eye lateral. Scales rather small, minutely ciliated. Two dorsals, the first with eight or nine spines; ventrals jugular; the lower pectoral rays branched. Villiform teeth in the jaws, none on the palate. Operculum without spine; præoperculum entire. Six branchiostegals; pseudobranchiæ. Air-bladder none; pyloric appendages in small numbers. There are two species, both from the seas off the southernmost part of America.

Epicopus. Body elongate, compressed posteriorly; snout long, depressed, with the cleft of the mouth wide, and with the lower jaw rather longer. Eye lateral. Scales small. Two dorsals, the first with nine or eleven feeble spines; ventrals jugular, with one spine and six soft rays; the lower pectoral rays branched. Jaws, vomer, and palatine bones with strong cardiform teeth. Opercles not armed. Branchiostegals six; gill membrane not joined to the isthmus underneath. The only species known was obtained from the coast of Chili.

Percophis. Cylindrical, very elongate; cleft of the mouth nearly horizontal, with the lower jaw very prominent; eye lateral. Scales small, ctenoid. Two separate dorsals, the first with about ten spines; ventrals jugular; the longer pectoral rays branched. Teeth in the jaws, on the vomer, and on the palatines, with very strong canines. Operculum with small spines; præoperculum entire. Seven branchiostegals; pseudobranchiæ. Air-bladder none; pyloric appendages. The only species known is Brazilian.

Chœnichthys. Body rather elongate, slightly compressed; head very large, with the snout spatuliform, and with the cleft of the mouth very wide, and the lower jaw longest. Eye lateral. Scales none; lateral line with granulated plates. Two dorsals, the first with seven spines; ventrals jugular; the lower pectoral rays branched. In both the jaws cardiform teeth; palate smooth. Opercles armed. Six branchiostegals; gill membrane joined to the isthmus underneath; pseudobranchiæ. Air-bladder none; pyloric appendages in small number. There is but one species, which was procured from Kerguelen's Land.

Bovichthys. General aspect cottoid; posterior portion of body compressed; cleft of the mouth horizontal; with the upper fin rather longer; eye lateral, more or less directed upwards. Scales none. Two separate dorsals, the first with eight spines; ventrals jugular; the lower pectoral rays simple. Villiform teeth in the jaws, in the vomer, and palatine bones, without canines. Operculum with a strong spine; præorbital and præoperculum not armed. Seven branchiostegals. There are three species, which occur in the seas off South America and Australia.

Trachodon. Body compressed, elongate, with the abdomen trenchant; cleft of the mouth nearly vertical; eye lateral; scales none. Two dorsals; the spinous low, but as long as the soft; ventrals thoracic; the lower pectoral rays simple. Villiform teeth in the jaws and on the vomer; none on the palatine bone. Præorbital and præoperculum armed. Five branchiostegals. The only species known lives on the coast of Kamtchatka.

The third group, or *Pinguipedina*, has the head more or less compressed, and covered with scales. The eye is lateral. The lateral line is continuous. The intermaxillary has a larger tooth on its posterior portion (labroid). Air-bladder present. It contains two genera.

Pinguipes. Body cylindrical; cleft of the mouth slightly oblique; eye lateral; scales small, minutely ciliated. One continuous dorsal, with five to seven spines; ventrals thoracic, or a little before the pectorals; the lower pectoral rays branched. A villiform band of teeth in the jaws, with strong outer ones; teeth on the vomer and palatines. Operculum with small spines; præoperculum entire. Six branchiostegals. Air-bladder present; pyloric appendages in small number. There are three species, all of which have been obtained from the coasts of South America.

Latilus. Body rather elongate, slightly compressed; cleft of the mouth horizontal, with the jaws equal; eye lateral. Scales small, finely ciliated. One continuous dorsal, with four to eight spines; ventrals thoracic, or somewhat in advance of the pectorals; the lower pectoral rays branched. Villiform teeth in the jaws, with canines; none on the palate. Operculum without spine; præoperculum denticulated. Six branchiostegals; pseudobranchiæ. Air-bladder simple; pyloric appendages in small number. Five species are recorded. The range is from the Indian Archipelago and the Chinese Sea on the west, to the coasts of Chili and Brazil on the east.

The fourth group, or *Pseudochromides*, has the eyes more or less lateral; the head not cuirassed; and the lateral line interrupted. It embraces the six following genera:—

Opisthognathus. Body rather elongate, rounded anteriorly, slightly compressed posteriorly; the upper profile of the snout parabolic; cleft of the mouth large; the upper maxillary produced backward; eye lateral, large. Scales small, not ciliated. Lateral line not continued to the caudal. One dorsal, with the unarticulated rays flexible; ventrals jugular; the lower pectoral rays branched. In both the jaws fine cardiform teeth; palate smooth. Opercles not armed. Six branchiostegals; the gill membranes joined together inferiorly; pseudobranchiæ. Air-bladder small; pyloric appendages none. There are five species. Three species occur in the Indian Ocean, and the other two on the east coast of South America.

Pseudochromis. Head and body rather compressed, more or less elongate; cleft of the mouth rather oblique, with the lower jaw longest; eye lateral. Scales of moderate size, ciliated; lateral line interrupted. One dorsal with a few spines anteriorly; ventrals thoracic; the lower pectoral rays branched. Jaws with cardiform teeth, anteriorly with canines; vomer and palatine bones toothed. Præoperculum entire. Six branchiostegals; the gill membranes joined inferiorly; pseudobranchiæ and air-bladder present; pyloric appendages none. It includes eight species, which occur in the seas between the Red Sea on the one hand, and that which surrounds the Philippine Islands on the other.

Cichlops. Head and body rather compressed, more or less elongate; cleft of the mouth oblique, with the lower jaw longest; eye lateral. Scales of moderate size, ciliated; lateral line interrupted. One dorsal with a few spines anteriorly; ventrals inserted below or before the pectorals; the lower pectoral rays branched. Jaws with cardiform teeth, anteriorly with canines; vomer toothed; palatine bones toothless. Præoperculum entire. Six branchiostegals; pseudobranchiæ and air-bladder present; pyloric appendages none. There are three species, all of which occur in the seas surrounding the East Indian Archipelago.

Pseudoplesiops. Head and body rather compressed, oblong; jaws equal anteriorly; eye lateral. Scales of moderate size, cycloid; lateral line interrupted. One dorsal without spines; ventrals jugular, without spines. Jaws and vomer with a band of teeth, the former with canines; palatine bones toothless. Præoperculum entire. Six branchiostegals; pseudobranchiæ entire. Only one species is known, from the Sea of Goram.

Notothenia. Body more or less elongate, slightly compressed posteriorly, rounded anteriorly with the head depressed; cleft of the mouth slightly oblique, with the lower jaw longest; eye directed upwards. Scales rather small, ciliated; lateral line interrupted. Two dorsals, the first separated from the second by a very deep notch, with the spines flexible (in one species stiff); ventrals jugular; the lower pectoral rays branched. In both the jaws cardiform or villiform teeth; palate smooth. Operculum with two obtuse points; præoperculum entire. Six branchiostegals; the gill membranes joined inferiorly; pseudobranchiæ. Air-bladder none; pyloric appendages in small numbers. There are nine species, all natives of the seas surrounding the South Pole.

Harpagifer. Habit cottoid. Scales none; lateral line not continued to the caudal. Two dorsals, the first with three or four flexible spines; ventrals jugular; the lower pectoral rays branched. In both the jaws villiform teeth; palate smooth. Operculum and sub-operculum with very long spines. Six branchiostegals; the gill membrânes attached to the isthmus between; pseudobranchiæ. Air-bladder none; pyloric appendages in small number. There is but one species, which has been found off Cape Horn and the Falkland Isles.

(Günther, *Catalogue of the Acanthopterygian Fishes in the Brit. Mus. Coll.* vol. ii.)

TRIOPTERYS, a genus of plants the species of which flourish in tropical America. The flowers have a purple or violet hue, and the mature fruit is three-lobed, each lobe being provided with three wing-like appendages. It is from this last character that it obtains its generic name of *Triopterys*, or the three-winged. A few species are cultivated in this country.

TROGLODYTES, a genus of anthropoid apes, of which some three or four, perhaps more, species are known. One of these, the Chimpanzee, is noticed under CHIMPANZEE, E. C. i. cols. 1019—1022, and a second species, the Gorilla, is also cursorily described. In addition to these we are now acquainted with the *Troglodytes Aubryi* of Gratiolet, *T. Kooloo-Kamba*, *T. calvus*, and possibly one or two others. At present, however, there does not seem to be more than three well-established species, viz., the Chimpanzee, the Gorilla, and Gratiolet's species. Of late years great interest has been taken in these apes, mainly owing to the conviction manifested by some of the most eminent anatomists and physiologists of the present century, that of all the forms of animal life these approach most nearly to man, so far as concerns the structure of the body. All the species are inhabitants of the west coast of equatorial Africa, and as they live either in the same or in closely contiguous districts, while most of the older accounts of them have been derived from the natives, not from actual observation, it has naturally happened that the species have been confused together, and that the habits of one have been applied to another. The imperfect descriptions, the superstitions of the natives, and many other circumstances, have rendered the older accounts very obscure.

These apes are so far like men that the native Africans generally believe them to be such, and, in accordance therewith, call them men and women, terms which have been adopted by old voyagers along with husband and wife, and which give a certain quaintness to their narrations. One of the earliest voyagers to equatorial Africa was Hanno, who is supposed to have lived in about the sixth century before Christ. He proceeded along the west coast as far south, probably, as Fernando Po, or one of the other islands in the Gulf of Guinea. Respecting the furthest limits of his voyage, he has the following remarks, as rendered by Falconer. "On the third day after our departure thence, having sailed by those streams of fire, we arrived at a bay called the Southern Horn, at the bottom of which lay an island like the former, having a lake, and in this lake another island, full of savage people, the greater part of whom were women, whose bodies were hairy, and whom our interpreters called Gorillæ. Though we pursued the men we could not seize any of them; but all fled from us, escaping over the precipices, and defending themselves with stones. Three women, were, however, taken; but they attacked their conductors with teeth and hands, and could not be prevailed on to accompany us. Having killed them, we flayed them, and brought their skins with us to Carthage. We did not sail further on, our provisions failing us." This passage has been thought to apply to the chimpanzee by some, and, probably influenced by the name, to the gorilla by others. It is not sufficiently definite for us to say what species was referred to. Certainly the creatures were not real men and women, but some species of ape. Along the coast of equatorial Africa there are several kinds of apes, and the passage recalls to mind one of the baboons rather than the anthropoid forms mentioned. The species of *Troglodytes* are essentially tree-climbers, seldom descending to the ground, except when crossing short spaces in the forest. The baboons, on the other hand, are excellent rock-climbers. Baboons are commonly gregarious, whereas chimpanzees and gorillas do not generally occur in large herds. Baboons are very strong, but may be captured alive by a few powerful men, whereas it would be very difficult to perform the same feat with the chimpanzee, and it is doubtful if it has even been done with mature gorillas which have not been enfeebled by wounds. Baboons generally fly away from man, seldom making any very vigorous defence, whereas in the case of the gorilla, it usually happens that the male is ready to defend the females and young against any enemy that approaches. In short, the narrative applies more accurately to the drill or to the mandrill than to any of the other apes known to frequent this district.

In the sixteenth century, Andrew Battel, a native of Leigh, in Essex, was taken prisoner by the Portuguese, and by them compelled to carry on trading operations for them with the natives of Angola, Congo, and Loango. His stay in those countries extended over eighteen years, and the results of his observations form a portion of that quaint old collection of travels which Purchas brought together. Battel, in describing the province of Mayumba, mentions a great river, called Banna, which is said to be closed by a bar in the winter months, but to be open to navigation in the summer; a description which would apply to the Fernand Vaz river. The woods in this locality, he states, are covered with "baboones, monkies, apes, and parrots;" but besides these there are two kinds of monsters which are both common and dangerous. "The greatest of these two monsters is called Pongo in their language, and the less is called Encégo. The pongo is in all proportions like a man, but that he is more like a giant than a man; for he is very tall and hath a man's face, hollow-eyed, with long hair upon his browes. His face and eares are without hair, and his hands also. His bodie is full of haire, but not very thicke, and it is of a dunnish colour. He differeth not from a man, but in his legs, for they have no calfe. Hee goeth always upon his legs, and carrieth his hands clasped on the nape of his necke when he goeth upon the ground. They sleep in the trees, and build shelters for the raine. They feed upon fruit that they find in the woods, and upon nuts, for they eat no kind of flesh. They cannot speak, and have no understanding more than a beast. The people of the countrie when they travaile in the woods make fires where they sleepe in the night, and in the morning, when they are gone, the pongoes will come and sit about the fire till it goeth out, for they have no understanding to lay the wood together. They goe many together, and kill many negroes that travaile in the woods. Many times they fall upon the elephants which come to feed where they be, and so beate them with their clubbed fists that they will run roaring away from them. Those pongoes are never taken alive, because they are so strong that ten men cannot hold one of them; but yet they take many of their young ones with poisoned arrows. The young pongo hangeth on his mother's bellie, with his hands fast clasped about her, so that when the countrie people kill any of the females they take the young one, which hangeth fast upon his mother. When they die among themselves they cover the dead with great heapes of boughes and wood which is commonly found in their forests." This account is wanting in precision and accuracy, but is so far important that the name for the chimpanzee amongst the natives of the present day is that which Battel applied to the lesser of the monster apes. The word is spelt in various ways, since each author attempts to express as nearly as possible the sound. Tnchego, ntchego, nchego, nshiego, are examples of the mode of spelling. The pongo, then, is probably some ape larger than the chimpanzee, but the account seems to refer to two or more species of *Troglodytes*. The great strength attributed to the pongo could hardly be assigned to any other ape than the gorilla; many of the other details, such as the size, the long-haired brow, the shape of the legs, and the habit of the young, are true of the gorilla, but they are also true of other apes than it. The formation of a shelter from rain is not the gorilla's habit, but it is that of the species or variety which Du Chaillu calls *Troglodytes calvus*. The name pongo does not seem to be known to the natives now, and it does not appear to be a misapplication of the name of the Mpongwe tribe to the ape, since this tribe was unknown on the coast in Battel's time, and first arrived at their present locality in the present century. Formerly they lived far in the interior. The native name now is *ngena*, which, like nshiego, has been spelt in many ways.

In 1699 appeared the first full anatomical description of an anthropoid ape. It was written by Tyson, and was based on a young male chimpanzee. It is so exhaustive and accurate that it still retains a high place in the literature of the subject. In 1766 Buffon and Daubenton published their accounts of the structure and habits of the chimpanzee. After this, numerous scattered notices of *Troglodytes* were published; but it is not until 1774 that we have an apparent reference to the gorilla. In that year appeared the first volume of Lord Monboddo's work on the origin of language, in which is inserted a letter from Mr. Bell, describing three species of anthropoid apes as existing on the west coast of Africa. "The first and largest is by the natives of Loango, Malemba, Calenda, and Congo, called or named Impungu. This wonderful and frightful production of nature walks upright like a man, is from seven to nine feet high when at maturity, thick in proportion, and amazingly strong; covered with longish hair, jet black over the body, but longer over the head; the face more like the human than the chimpanza, but the complexion black, and has no tail. When this animal sees a negroe, it mostly pursues and catches them; it sometimes kills them, and sometimes takes them by the hand and leads them along with them. Some that have made their escape say that this animal when it goes to sleep does not lie down, but leans against a tree. In this position, when the prisoner finds it asleep, he steals away the hand or arm softly from his, and so steals away quietly—sometimes discovered and retaken. It lives on the fruits and roots of the country, at the expense chiefly of the labour of the natives; and when it happened to be where there is no water, there is a tree with a juicy bark, which it strikes with its hand, bruises, and sucks the juice; and some of this tree it often carries with it when it travels, in case it should not find it or water by the way. And, indeed, I have heard them say that it can throw down a palm tree by its amazing strength, to come at the wine. I never saw this animal; but there was a young one brought down from the inland country to the king of Malemba, which is next to Calenda, while my son was there. The people that brought it down said that it was quiet and composed the several months they had it; eating and taking its victuals and drink quietly. It was brought down with a yoke about its neck, and its hands tied like the other slaves that came with it, and came down quietly. But when it came to the king's town, such amazing crowds came to see it from all quarters, it grew sullen and sulky; for being so exposed it would eat no victuals, and died in four or five days. It was young; about six feet and a half high. I have never seen this animal, nor my son; but he, in his last voyage, saw the hand of one of them cut off, about four inches above the joint of the wrist. It was dried and withered; yet in that state its fingers were as big as three of his, or bigger than his wrist, rather longer than the proportion of ours; and the part where cut off, in that wrinkled state bigger than the biggest part of his arm; the upper part of the fingers, and all the other parts, covered with black hair; the under part like the hand of a negro. It is said to be the strongest of all the beasts of the wood, and all are afraid of it. I have not heard of this animal anywhere than on the coast of Angola." Much of this seems to be based upon hearsay evidence, as indeed it purports to be; but the dimensions are much exaggerated, unless it refers to an anthropoid ape still larger than the gorilla, which hardly seems likely. He then describes the habits of the chimpanzee, which is said to be the smallest of the three species. Lastly, he refers to a species intermediate in size between the chimpanzee and impungu, which resembles the chimpanzee in every respect but size. It does not agree with the chimpanzee, and is never associated with that species. He calls it the Itsena, which may be the same as Ngina, the native name for the gorilla. No details are given about it, but if the gorilla is intended, there is still a large ape to be discovered. It is possible that the impungu is the gorilla, and the itsena may be either the *Troglodytes Kooloo-Kamba* of Du Chaillu, or the *T. Aubryi* of Gratiolet.

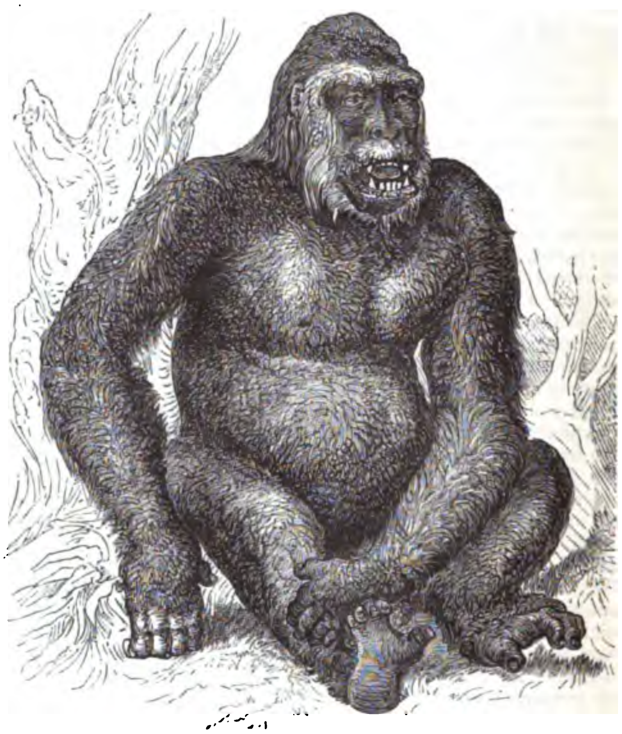
In 1819, Bowdich says he had heard of an ape at the Gaboon called Ingena, which was five feet in height and four across the shoulders, which built a rude house, and slept on the outside of it. This will apply to the gorilla.

In 1835 Professor Owen described the skeleton of an adult chimpanzee. In 1841 Professor Vrolik published an elaborate memoir on the anatomy of the same species. In 1846 Walker obtained the first unquestionable evidence relative to the gorilla in the form of two skulls. In 1847 he obtained various other portions of the animal, which were forwarded to and reported on by Messrs. Savage and Wyman, of Boston. According to Dr. Savage the gorilla is about five feet high, exceedingly broad-shouldered, and covered with black hair, but in old specimens the black turns to grey. The most prominent features about the head are the great width and elongation of the face, the massiveness of the jaws, and the hairy ridge on the head, which the creature can bring down over its beetling eyebrows so as to add greatly to its ferocious aspect when enraged. It progresses by a shuffling gait, the body never being so upright as in man, but bent forward. From the bulk of its body and the shortness of its legs, it waddles and rolls when walking. The usual mode of progression on the ground is by resting the knuckles on the ground, and moving itself forward on its long arms by a sort of half jumping, half swinging motion, like that of a man on crutches. When it rises on its hind legs, which is only done on rare occasions and for short distances, it secures the balancing of its body by swinging the arms upward and over its head. It lives in small bands, generally composed of one adult male and several females and young individuals. Not unfrequently, however, they are met with singly or in pairs. The dwellings formed by it are like those of the chimpanzee, consisting of a platform of sticks and branches, without any special protection from rain. These are occupied at night only. The gorilla is to a certain degree offensive in its habits; for, being the strongest animal in the forest, it flies from nothing, and on the approach of any foe, the old males at once advance to the defence of the band. "It is said," remarks Dr. Savage, "that when the male is first seen he gives a terrific yell that resounds far and wide through the forest, something like *Kh——ah! Kh——ah!* prolonged and shrill. His enormous jaws are widely opened at each expiration, his under lip hangs over the chin, and the hairy ridge and scalp is contracted upon the brow, presenting an aspect of indescribable ferocity. The females and young at the first cry quickly disappear; he then approaches the enemy in great fury, pouring out his horrid cries in quick succession. The hunter awaits his approach with his gun extended; if his aim is not sure, he permits the animal to grasp the barrel, and as he carries it to his mouth (which is his habit), he fires; should the gun fail to go off, the barrel (that of an ordinary musket, which is thin,) is crushed between his teeth, and the encounter soon proves fatal to the hunter. The food consists of the subacid pulpy fruits of species of *Amomum*, the sweet stem of the sugar-cane, and various parts of the oil palm or *Elais guineensis*, *Carica papaya*, *Musa sapientum*, and several other plants."

The osteological specimens obtained by Dr. Savage were submitted to Mr. Wyman's attention, who pointed out the leading peculiarities of the skull, and how the anatomical structure indicated the gorilla's arboreal habits and general unfitness for assuming an erect attitude. The conditions for walking erect are the nearly even balance of the head on the atlas; the double curvature of the vertebral column so as to bring the centre of gravity into the pelvic plane; the verticality of the axes of both the thigh and the leg; and the articulation of the feet at right angles to the axis of the leg, so as to permit of the sole resting flatly on the ground. All these conditions are wanting in the gorilla. Thus the foramen magnum, which is near the middle of the base of the cranium in man, is near the posterior third in the gorilla, so that the head tends to lean forward. The vertebral column forms a single curve, with the concavity on the ventral side, a circumstance which, taken in conjunction with the prominent abdomen, renders even the assumption of the semi-erect position irksome, owing to the force of gravity drawing the body forward. In order that the animal can stand up at all, it is obliged to bend its knees, so as to bring the centre of gravity more under itself. The feet are articulated almost vertically with the leg, a position which is highly favourable for arboreal locomotion, but unfavourable to terrestrial progression, since the feet are then inverted, and the animal is supported on the outer edge of its foot.

In 1851 Owen published a full description of the skeleton of the gorilla, and two years afterwards a comparison between it and the osseous framework in the chimpanzee and the negro. In 1852 and subsequent years Isidore Geoffroy St. Hilaire made various communications on the same subject to the Academy of Sciences at Paris. In 1855 Duvernoy made further contributions of a highly important character towards the knowledge of this animal's structure. In 1854 Gratiolet gave the first accurate description of the brain of the chimpanzee, which was followed in 1860 by a less complete account of the gorilla's brain.

In 1861 Du Chaillu's book on Equatorial Africa contributed considerably towards our knowledge of the anthropoid apes. He says the gorilla lives in the loneliest and darkest portions of the jungle, preferring the deep valleys and rugged heights where most wooded. It is exceedingly nomadic in habit, seldom staying more than a few days in the same locality. It eats enormous quantities of food, which consists entirely of vegetables. According to him it does not live much on the trees. He always found the gorillas on the ground, although they frequently climb after nuts and fruits, which, however, are eaten on the ground. It is fond of the wild sugar-cane, and of the white ribs of the pineapple leaf; but will also eat numerous kinds of berries, the piths of some trees, and a nut with a very hard shell, which is so tough that it requires a strong blow with a heavy hammer to break it. It is supposed that the gorilla crushes it with his jaws, which are known to be of surpassing strength from the facility with which the barrel of an old Birmingham can be crushed between them. The young only sleep on the platform of twigs in the trees, while the old ones generally sleep on the ground. Du Chaillu believes the old male always sleeps in a sitting position at the foot of a tree, or elsewhere on the ground. He describes the gorilla's loud voice, and its immense strength, which is said to vastly exceed that of the strongest boxer the world ever saw. Its mode of meeting an enemy is thus described by him:—"The gorilla advances by short stages, stopping to utter his diabolical roar, and to beat his vast breast with his paws, which produce a dull reverberation as of an immense bass drum. Sometimes from the standing position he seats himself and beats his chest, looking fiercely at his adversary. His walk is a waddle from side to side, his hind legs—which are very short—being evidently somewhat inadequate to the proper support of the huge superincumbent body. He balances himself by swinging his arms, somewhat as sailors walk on shipboard; and the vast paunch, the round bullet head, joined awkwardly to the trunk with scarce a vestige of



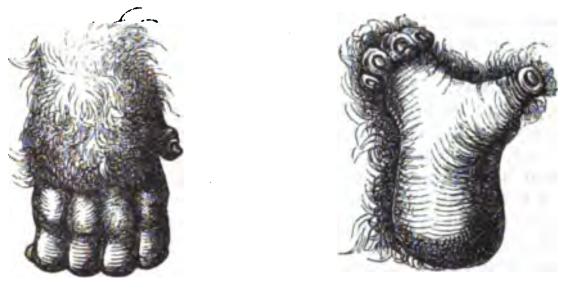
Front view of *Troglodytes Gorilla.*

neck, and the great muscular arms and deep cavernous breast, give to this waddle an ungainly horror, which adds to his ferocity of appearance. At the same time the deep-set grey eyes sparkle out with gloomy malignity; the features are contorted in hideous wrinkles, and the slight sharply cut lips, drawn up, reveal the long fangs and the powerful jaws, in which a human limb would be crushed as a biscuit." Ordinarily, he says, the gorilla walks on all fours, not on its hind legs. The height varies, and has about the same range as in man, or from five feet to upwards of six feet. The largest specimen measured by him was 5 ft. 8 in., but he saw portions of a skeleton which was far larger than any he possessed, and which he conjectured must have been at least 6 ft. 2 in. high. The females are much smaller than the males, and are seldom more than five feet high. The same author gives many details on the proportions and structure of the various parts of the body. He also gives accounts of the chimpanzee, as also of two other species, which he calls *Troglodytes calvus*, and *T. Kooloo-Kamba*. *T. calvus* is called nshiego mbouve by the natives, and is restricted to a very limited area in the dense forests on the table land of the interior. It is smaller and weaker than the gorilla, and builds a sheltering place for itself in the trees. The shelter is made so compactly of leaves as to exclude a great deal of the rain. The roof is umbrella-shaped, about six or eight feet across, and the branches are tied to the trunk of the tree by means of vine stems. The whole contrivance is said to show great ingenuity and intelligence. *T. Kooloo-Kamba* is very rare; and Du Chaillu only saw one specimen. He says "it is smaller than the adult male gorilla, and stouter than the female gorilla. The head is its most remarkable point. This struck me at once as having an expression curiously like to an Esquimaux or a Chinaman. The face is bare and black. The forehead is higher than in any other ape, and the cranial capacity greater by measurement proportionally to size. The eyes are wider apart than in any other ape. The nose is flat. The cheek bones are high and prominent, and the cheeks sunken and lank. The ridge over the eyes is well marked. The muzzle is less prominent and broader than in the other apes. The sides of the faces are covered with a growth of straight hair, which, meeting under the chin like the human whiskers, gives the face a remarkably human look. The arms reach below the knee. The hair on the arm meets at the elbow, growing upwards on the forearm, and downwards on the arm. The body is hairy. The shoulders are broad, the hands long and narrow, showing it to be a tree-climber. The arms and hands are very muscular. The abdomen is very prominent, as it is in the gorilla. The ears are very large, and are more nearly like the human ear than those of any other ape." Du Chaillu devotes a whole chapter to the skeleton of the African anthropoid apes, the details being partly drawn from other authorities, and partly based upon his own observations.

Side view of *Troglodytes Gorilla*.

From 1861 onwards scarcely a year has passed without some important memoir on one or more of the species of *Troglodytes*. In 1861 Wilder's contributions to the comparative myology of the chimpanzee appeared. In 1862 appeared Owen's memoir on the osteology of anthropoid apes—one of a long series of memoirs which commenced in 1848. In 1863 were published works by Barkow, Meyer, and Embleton; in 1864, memoirs by Thompson, Bianconi, Crish, and Gibb; in 1865, another memoir by Owen, which is devoted almost exclusively to the gorilla. In it he gives minute details in support of his view that the gorilla comes nearer to man than the chimpanzee or any other ape. In 1866 appeared the elaborate memoir on the anatomy of *Troglodytes Aubryi* by Gratiolet and Alix, a work which every student of the genus ought to consult. It is far too long (extending to 263 pages) for abstraction here; but we may give the following summary of the conclusions which the authors arrived at.

Referring to the opinion of some authors, such as Savage, Wyman, Owen, and Huxley, that the gorilla and chimpanzee belong to the same genus, and of others, such as Duvernoy, Isidore Geoffroy St.-Hilaire, Jules and Edouard Verreaux, that they are generically distinct, it is pointed out that Gratiolet also shared in the last-mentioned view. In any case, it would seem there is a unanimity of belief that the gorilla and the other species of *Troglodytes* form two separate groups. In some respects, such as the presence of five tubercles on the last lower molars, the degree of prognathism, and the heaviness of build, *T. Aubryi* approaches the gorilla; but in almost every other respect it belongs to the chimpanzee group. Its large ears are in marked contrast with the small ones which the gorilla has; the fore limbs reach below the knee; the hands have palms longer than wide; the zygomatic arches do not have a double curvature; the temporal crests are far apart, and do not unite in the median line; the cervical spines are shorter than those of the gorilla; and the scapula is narrow and long. The pelvis is longer, the sacrum narrower, than in the gorilla, and more like the same parts in the chimpanzee. The thumb is shorter in proportions than that of the gorilla, and the arm is quite as long as the forearm, not longer. In the form of the skull and of the face it is more like the chimpanzee than the gorilla. The myology of the chimpanzee and gorilla presents few distinctive points; but *T. Aubryi* agrees with the chimpanzee group rather than with the gorilla. On the whole, then, if *Troglodytes* be split up into two genera, *T. Aubryi* should be placed along with the chimpanzee.



Hand and foot of *Troglodytes Gorilla*.

T. Aubryi has a general resemblance to man, but the differences become more prominent than the resemblances when the organs are studied in detail; and these differential points are usually referable or rather correlated with the tree-climbing habits and feeble intelligence of the ape.

In 1867 Bischoff made a comparison between the skulls of the gorilla, the chimpanzee, and the orang-outan, with a reference to the bearing of the facts upon Darwin's theory as to the origin of species; and in 1868 the peculiarities of all the apes were pointed out in a comprehensive manner by Mivart in his memoir on the osteology of the *Primates*. In it there is much information as to the anthropoid apes. In the many memoirs which have been alluded to above there are numerous interesting questions discussed, and a crowd of facts enunciated, for which the reader must consult the originals. The accompanying cuts represent the general form and proportions of a large male gorilla, and are taken from the specimen in the Museum of the Anthropological Society of London.

(Sanford, *Am. J. Sci.* 2nd Series, vol. xxxiii. pp. 48—64; Wilder, *Journ. Bost. Soc. Nat. Hist.* vol. vii. pp. 352—384; Embleton, *Nat. Hist. Rev. for* 1864, pp. 250—258; Owen, *Trans. Zool. Soc.* vols. iii., iv. and v.; Meyer, *Die Gorilla mit Berücksichtigung der Unterschiedes zwischen Menschen und Affen und der neueren Umwandlungstheorie der Arten*, 1863; Reade, *Savage Africa*, 1863; Hanno, *Voyage*, translated by Falconer; Gratiolet and Alix, *Recherches sur l'Anatomie du Troglodytes Aubryi, Chimpanzé d'une espèce nouvelle*, in *Nouvelle Archives du Mus. d'Hist. Nat.* ii. pp. 1—264, 1866; Bischoff, *Ueber die verschiedenheit in der Schädelbildung des Gorilla, Chimpanse, und Orang Outang, vorzuglich nach Geschlecht und Arten nebst einer Bemerkung über die Darwinische Theorie*, 1867; Mivart, *On the Appendicular Skeleton of the Primates, Phil. Trans.* 1868.)

V

VIPERIDÆ. In the E. C. a reference is made from CAUDISONA to VIPERIDÆ, but was not fulfilled. In the re-issue the reference was altered so as to apply to the present heading. The genus, however, belongs to the rattlesnake group, *Crotalidæ*, and is entirely restricted to the central regions of America. According to Cope, the species naturally group themselves into two sections, according as the muzzle is crowned with three pairs of symmetrical shields in contact, or with a number of small plates. The first section embraces four species, which range from Brazil on the south to New Mexico on the north. The species of the second section are 13 in number, and as a group have a more northern distribution than the first section, ranging from Mexico to California, Georgia, and Arizona.

(Cope, *Proc. Philad. Acad. for* 1866, p. 308.)

W

WELWITSCHIA. A genus of plants belonging to the order *Gnetaceæ*, and based upon a singular plant which was discovered by Dr. Welwitsch in 1860 on the dry sandy plateau of Benguela, in Western Africa. In 1861 Baines found it in the Damara country; and in 1862 Mr. Monteiro collected some specimens in the dry sandy district of Mossamedes, or Little Fish Bay; and in the same year Andersson obtained it in the arid flats about Waalfisch Bay. All these belong to the same species, *W. mirabilis*, so that its range is from about 14° S. to about 23° S. It is a woody plant, forming a short trunk about two feet long, which, however, rises a few inches only above the soil, while its circumference is sometimes as much as 14 feet. In appearance it looks like a round table formed of dark brown wood, and having the surface cracked in all directions. On the external surface of the trunk are deep grooves, from which arise two exceedingly large leaves, whose dimensions sometimes attain six feet in length. These leaves are flat, narrow, and usually split up into numerous slips, which lie trailing on the ground, curled up into all kinds of curious contortions. These leaves are the cotyledons themselves—a fact which is supported by the authority of Dr. Welwitsch. Immediately above the insertion of the leaves, and consequently at the circumference of the woody tabular mass, spring bifurcated branched stems from six inches to a foot high, which support small erect scarlet cones with imbricated scales, and about the size of the spruce-fir cones when mature. The cones are either hermaphroditic in structure, but not in function, or female. It is closely allied to *Ephedra* and *Gnetum*, but differs from them, and indeed all known gymnosperms in wanting disc-bearing wood cells. In the absence of these cells, in the hermaphrodite flowers, and in the mode of impregnation of its secondary embryo sacs, it is intermediate in nature between angiospermous and gymnospermous plants.

Dr. Hooker has given full details respecting the structure and minute analogy of this plant in the undercited memoir, which is illustrated with fourteen plates. After referring to the great interest which excited botanists on the discovery of *Rafflesia Arnoldii*, he remarks that the discovery of the present species is the most wonderful that has occurred in the present century from a botanical point of view. The structure of the vascular system, as also of the reproductive organs; the functional peculiarities of these last, and the mode of development, all reveal such singular anomalies as sometimes to appear quite opposed to some of the received fundamental axioms in botany. The plant is one of the most striking products of a land which abounds in organisms so different from the ordinary living forms as to seem to be subject to other laws than they. But, although anomalous at the present period, we have little doubt that these strange beings represent what was the prevailing state of things at a period long gone by. The fauna and flora of Western Africa are, to speak metaphorically, outliers of the present period, the main mass having existed in some former geological age. There is scarcely another place on the globe where the peculiarities of past life are so richly displayed in the living world.

We have noticed above that the *Welwitschia* thrives in the most arid wastes, which seldom or never receive any rain throughout the year. But it must not be supposed that because rain does not fall that moisture is scarce. In these regions the air is intensely hot, but contains a very large quantity of aqueous vapour, which is suspended during the day. At night, when the temperature sinks, the vapour is condensed, and the country is so immersed in dew, that it is said that parties may travel through the driest areas near the coast, yet never want water, provided they take means to collect it at night.

(Hooker, *Trans. Linnæan Soc.* xxiv. p. 1.)

X

XIPHOTEUTHIS, a genus belonging to the family *Belemnitidæ*, and remarkable for the extraordinary form of its *proostracum*, which is exceedingly well shown in some beautiful specimens recently obtained by Mr. Day from the middle lias of Dorsetshire. The ordinary belemnite is generally represented in the fossil condition by a portion of its internal skeleton. This portion is the hollow cone or *phragmacone*, which is divided into chambers by means of septa, somewhat in the same way as in the chambered shell of the nautilus. The tapering extremity or apex of this cone is, in the animal, enveloped by a solid body, called the *guard* or *rostrum*. Attached to the sides of the phragmacone, and projecting in front of it, is a thin laminated nacreous sheath, which protected the ink-bag and other soft parts, and is supposed to be either homologous or analogous with the *pen* in *Loligo*. In most Belemnites the form of the *pro-ostracum* is more or less oval. In *Xiphoteuthis elongata* the same parts occur as in *Belemnites*. The specimen found by Mr. Day shows the guard enclosing the phragmacone. The upper termination (or what appears to be such) of the phragmacone is coated with a layer of shelly matter, which passes forward into the pro-ostracum, which was nearly a foot long when entire. Posteriorly it is flat, and about one-third of an inch wide, but gradually narrows to the fifth of an inch; then widens to half an inch, after which it gradually tapers to a point. In shape, then, it resembles some old-fashioned sword.

(Huxley, *Memoirs of the Geol. Survey of the United Kingdom*, Monograph ii. 1864.)

Z

ZOAMYLINE. [Starch, E. C. S.]

ZOANTHARIA. [Actinozoa, E. C. S.]

ZOOLOGY. Some general remarks on classification are given under Birds, Bear, Hydrozoa, Actinozoa, and most of the other zoological articles in this Supplement.

THE END.

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